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THE UNIVERSITY OF ALBERTA

# A STUDY OF THE PIAGETIAN CONCEPT OF CLASSIFICATION AND READING COMPREHENSION

by

© MICHAEL E. C. LUPART

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "A Study of the Piagetian Concept of Classification and Reading Comprehension" submitted by Michael E. C. Lupart in partial fulfilment of the requirements for the degree of Master of Education.

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C Kupchink

Date January 13, 1978

# ABSTRACT

Reading comprehension can be viewed as an active, dynamic, developmental thought process in which the reader relies on and applies both knowledge of language and logical operations to reconstruct the meaning of the text. The operations of classification are an integral component of this process. However, the acquisition and application of these operations are developmental. Task performance differences at a given age level may be attributed to: (1) the operations are not completely developed, (2) the operations are developed but are only applied to a concrete situation, and (3) the operations are developed and are generalized to a reading situation. Hence the major purpose of this study was to assess the extent to which sixth grade more proficient and less proficient readers, age 11 years 1 month to 12 years 4 months, could perform the Piagetian operations of classification in both a reading and concrete situation.

In this study 20 more proficient readers and 20 less proficient readers were selected from 219 subjects on the basis of performance on the New Developmental Reading Test: Intermediate Level. All subjects were assigned to two major conditions of classification, concrete and reading, and two major aspects of classification, additive classification and multiplicative classification. The aspect of additive classification was comprised of the dimensions, class construction, predication and class inclusion, and the aspect of multiplicative classification was comprised of matrix structure and intersection.

The two-way analysis of variance and Newman-Keuls procedure revealed significant differences between the two groups. Except for the aspect of multiplicative classification in the concrete situation, the more proficient readers performed significantly better than the less proficient readers in all aspects of classification. In addition, the statistical analysis of the data revealed that in the aspect of additive classification both groups of readers performed appreciably better in the concrete situation as compared to the reading situation. However, in terms of the multiplicative classification tasks, the pattern of better performance in the concrete situation was evident only in the performance of the less proficient readers. More proficient readers performed similarly in both the concrete and reading situation.

These findings indicate that the more proficient readers were more able to rely on and apply the operations of classification to the reading task than the less proficient readers. The findings also suggest that reading material within its nature may be more formal or abstract than the concrete verbal tasks.

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# CHAPTER I

## INTRODUCTION AND PURPOSE OF THE STUDY

Reading comprehension in this study is primarily viewed as thought or reasoning (Huey, 1968:302). Principally as Thorndike (1917:323) suggests reading comprehension involves the organization of facts and principles. In addition this involves the analysis of the ideas in a sentence or passage, and the reorganization of these elements in their proper relations. This process, according to Thorndike (1917:323), implicitly involves reasoning or thinking. The operations of thought however are not static but continue to change and develop.

Piaget (1970:15) views the development of human thought and intelligence in terms of genetic epistemology. Essentially this view suggests that the human being in his adaptation to the environment develops along certain specific stages, each interdependent upon the other, and each contributing to the following stage. Implicit within these stages is the development of the operations of logic and classes, which are essential to the development of higher order and succeeding operations. This view of logical development acquires special significance if one assumes as Goodman (1973: 61) suggests, reading is a meaningful active process. The reader must rely on his knowledge of verbal concepts, language and vocabulary, but in addition he must also be able to rely on and apply a sufficient repertoire of logical operations to fully reconstruct the meaning of the visual information presented. This view of reading encompasses the notion of reading comprehension as an active developmental thought process. In this sense the reader must be able to remember, translate, interpret, synthesize, analyze and evaluate the information he is attempting to reconstruct. What is suggested is that this reconstruction of the author's thought and also his own thought requires among other processes the primary operations of logical operations generally and specifically the logical operations of class relations. If one accepts this view of reading, and reading comprehension, then it become axiomatic that reading involves far more than just decoding the visual information at the literal level.

Jenkinson (1975), Henry (1974), Gerard (1975) and Rawson (1969) all point to the need for further research in the area of reading comprehension and the relationship of the logical operation of classification to reading comprehension.

Jenkinson (1975:2) suggests that a primary component of reading comprehension is the ability of the reader to identify the author's purpose. This requires that the reader fully understand the meaning of the prose at the literal level, and then attempt to construct a mapping, matrix or organization of the author's thoughts to understand the material at the inferential level (Jenkinson, 1975:2).

Jenkinson's view of reading comprehension is reflected in Rawson's research. According to Rawson (1969:4) an integral part of an individual reader's ability to comprehend what he reads is the ability of the reader to apply and rely on a number of previously learned logical operations. Those operations she chose to study were conservation, classification, deduction, induction, and probability reasoning.

Henry (1974:15) indicates that reading comprehension can be viewed as concept development and involves two primary modes of thought, analysis and synthesis. Basic to these modes of thought is the operation of classification and class relations. Class relations primarily involve the operation of negation, conjunction, implication and disjunction.

Gerard (1975:111) dealing on a much more operational level accepts a subordinate, superordinate view of reading comprehension, and suggests that reading comprehension should be taught through categorization and classification.

This view of reading comprehension suggested by Jenkinson (1975), Rawson (1969), Henry (1974) and Gerard (1975) by necessity involves the reader's use of logical operation in general and the reader's use of the logical operations of classification, specifically. It seems conceivable then that if readers are required to comprehend and think about what they read, they must have access to and be able to rely on and apply these operations to the reading task. However some readers may not have access to these operations in the concrete situation. On the other hand these readers may have access to these operations but experience difficulty in applying them to a reading context. Other readers may have equal access to these operations in both a reading and concrete situation. This essentially is the primary problem of this study, to assess the extent to which readers can perform the operations of classification in both a reading and concrete situation.

## PURPOSE OF THE STUDY

The major purpose of the study was to measure the extent to which sixth grade more proficient and less proficient readers, age 11 years 1 month to 12 years 4 months could perform the Piagetian operations of classification in both a reading and a concrete situation.

According to Piaget (1967:130), 11 to 12 year olds should be on the verge of formal operations, and thus should have access to these operations of classification. In essence subjects in this age group should be able to more consistently rely on these operations in a less familiar and more abstract situation. However it seems conceivable to the researcher that the less proficient readers, low comprehenders, may not as yet have access to these operations of classification in the concrete situation or may have access to these operations of classification in the concrete situation, but cannot apply them equally as well to the reading situation.

This study is an attempt to examine more closely the extent of this relationship, therefore subjects were selected from the age range which has experimentally been demonstrated to correspond to the entering of formal operations. Both more proficient and less proficient readers were included in the sample in an attempt to assess the extent of the availability and transferability of operations in the concrete situation and the reading situation.

## IMPLICATIONS

The summary of the research and the findings of the study suggest a number of important implications in the development of a more precise understanding of the psychological processes involved in the reading act. This would primarily involve the extent to which the operations of classification may contribute to the reader's comprehension and understanding, at an inferential level of prose. Furthermore the study could possibly provide numerous insights for the teaching of reading comprehension through the more specific application of the operations of classification.

## MAJOR DEFINITIONS OF TERMS

The following major definitions are used for this study.

### Subjects

The subjects are 20 more proficient and 20 less proficient readers of average to above average intelligence. The readers are all sixth grade students ranging in age from 11 years 1 month to 12 years 4 months. These subjects were selected from an initial group of 219 sixth grade, middle class students from five schools in the city of Edmonton.

### More Proficient Reader (MPR)

These are considered to be above average comprehenders. Specifically these are the 20 readers of average to above average intelligence (intelligence score 92 or greater) from the original group of 219 students whose performance on the New

Developmental Reading Test (NDRT) Vocabulary Subtest I is at or above the 50th percentile rank, performance on the NDRT Literal Comprehension Subtests is at or above the 50th percentile rank, and whose performance on the NDRT Creative Comprehension Subtests is at or above the 86th percentile rank. Percentile ranks are all based on test norms. The Literal Comprehension Subtests are Reading for Information II and Reading for Relationships III. The Creative Comprehension Subtests are Reading for Interpretation IV and Reading for Appreciation V.

### Less Proficient Reader (LPR)

These are considered to be below average comprehenders. Specifically, these are the twenty readers of average to above average intelligence (intelligence score 92 or greater) from the total population of 219 students, whose performance on the New Developmental Reading Test (NDRT) Vocabulary Subtest I is at or above the 50th percentile rank, performance on the NDRT Literal Comprehension Subtests is at or above the 50th percentile rank, and whose performance on the NDRT Creative Comprehension Subtests is at or below the 57th percentile rank. In addition the Creative Comprehension percentile rank score is below the Literal Comprehension percentile rank score. Percentile ranks are all based on test norms.

### Average and Above Average Intelligence

Average and above average intelligence is defined by performance on a recognized intelligence test administered by the schools that the subjects attend. This test must have been administered during the month of January 1977, and the subject's verbal and nonverbal IQ score must be considered average or above average as defined by test norms. In terms of the intelligence test used in this study the Canadian Lorge Thorndike Intelligence Tests, Level D, Form I, Nonverbal and Verbal Batteries, this is an intelligence score of 92 or greater on both the Verbal and Nonverbal Batteries.

## Reading Comprehension

Reading comprehension is defined as the understanding of written material in terms of Hunkins' Taxonomy, 1976 (Hunkins, 1976: 19-22). This taxonomy is derived from Bloom's Taxonomy and is closely related to the taxonomy suggested by Sanders (1966:1-54) and Smith and Barrett (1974:52-58) (Bloom, 1956:62-197). In general reading comprehension is assessed at six stages or levels: knowledge, comprehension, application, analysis, synthesis and evaluation.

## Literal Comprehension

Literal comprehension is considered to be the knowledge and comprehension levels (Hunkins, 1976:19-20). In general this is viewed as a factual-type of comprehension (Bowman, 1975:3).

## Inferential Comprehension (Creative Comprehension)

Inferential comprehension is considered to encompass the remaining four stages, application, analysis, synthesis and evaluation (Hunkins, 1976:21-22). Bowman (1975:3) describes this as a conceptual-generalization type category of comprehension. The level of reading comprehension of the 219 grade six students was determined by their performance on the New Developmental Reading Tests Intermediate

Level, Bond, Balow and Hoyt, revised 1968.

The subjects' Reading for Information II and Reading for Relationships III scores were combined to provide a total Literal Comprehension score.

The Reading for Interpretation IV and Reading for Appreciation V scores for each subject were combined to give a Creative Comprehension score. This Creative Comprehension score was viewed as an Inferential Comprehension score (Bond, Balow and Hoyt, 1968:18).

Reading Classification Tests (SCO)

Four passages, and corresponding questions, two of which are adopted and revised from Rawson (1969:326-330), and two of which are constructed by the researcher to measure the five dimensions of classification: construction of classes, class inclusion, predication, matrix classification, and intersection. (Appendices A, B, C and D.)

Concrete Classification Tests (CCO)

Five concrete tasks: construction of classes, class inclusion, predication, matrix classification and intersection items and corresponding questions were adopted and revised from Rawson (1969:331-325). (Appendices E and F.)

Concrete

This refers to the situation in which the concrete objects to be manipulated are present (Rawson, 1969:21).

Class

A class is defined as the sum totality of objects or elements which have a certain property.

$$\hat{F} = (x)\ f(x)$$

"The totality of objects (x) for which f(x) is true" (Rawson, 1969:18).

## Classification

Classification is defined as the cognitive operations which result in one of the following outcomes:

1. The criterial property "f" is abstracted and asserted in a predicate.

2. A class label is given to the objects or elements on the basis of common criterial properties.

3. Certain class inclusion relations hold between classes (Rawson, 1969:19).

## Property

The property is expressed by the predicate of a proposition. It is viewed as a characteristic, or attribute of a person or thing (Rawson, 1969:18).

e.g. The dog is black.

## Additive Classification

Additive classification is defined by the following criteria:

1. All the elements are classified and accounted for $(x)\varepsilon A$.

2. There are no isolated classes. For instance every specific class A is characterized by the property a. This class implies its complement $A'$ (not a). These classes are included in the superordinate class B.

e.g. The class of birds (A) is characterized by the property feathers (a). This class implies its complement not birds ($A'$) with the property not feathers (not a). These classes are included in the superordinate class animals (B).

3. All members having the property (a) will be included in the class A.

4. The class A will only include members having the property a.

5. The classes of the same rank are disjoint $A \times A' = 0$. (A cannot be A and not A at the same time.)

6. The complementary class $A'$ will have the characteristics $a'_x$.$(A' = A_x)$. These characteristics are not possessed by its complement A.

7. The class A or $A'$ will be included in the higher ranking class (B). This higher ranking class (B) will include all the elements of A. (All A are some B.)

$$A = B - A', \ B = A + A', \ A' = B - A.$$

8. Extensional simplicity. The inclusions in the classes constructed are reduced to a minimum. (Essentially the subject makes the fewest groupings or classes possible.)

9. Intensional simplicity. The attributes of the elements classified are reduced to as few as possible, to distinguish classes of the same rank. For instance if color is used as a criterion, this criterion would be used to distinguish classes in the same rank.

10. Symmetrical subdivision. In this case if the class B is segmented into $A_1$ and $A'_1$ and the same criteria are applicable to $B'_2$, then $B_2$ must also be divided into $A_2$ and $A'_2$ (Piaget and Inhelder, 1964:48).

### Multiplicative Classification

Multiplicative classification is a composite of two or more additive classifications, and thus the criteria and set of operations common to additive classification are also applicable to multiplicative classification. In addition four new criteria and two operations are added.

1. All the components of $B_1$ also belong to $B_2$. This is also applied vice versa, thus if $B_1 = A_1 + A'_1$

$$B_2 = A_2 + A'_2$$

then

$$B_1 \times B_2 = A_1A_2 + A'_1A'_2 + A_1A'_2 + A'_1A_2 = B_1B_2$$

2. All the components of $A_1$ must belong either to $A_2$ or $A'_2$. However if the components of $A_1$ belong to both $A_2$ or $A'_2$ then $A_2 \times A'_2 = 0$ (Piaget and Inhelder, 1964:152).

3. The classes $A_1$ and $A'_1$ contain only the elements belonging either to $A_2$ or to $A'_2$. The same is true vice versa.

4. Each of the associations of $A_1A_2$ and $A'_1A'_2$ comprise only one multiplicative class (Piaget and Inhelder, 1964:153).

## MINOR DEFINITIONS

The following minor supporting definitions are used in the study.

### Singular Propositions

Singular propositions attribute a property to a thing, object or individual. The proposition is comprised of a name, and an attribute of that name is asserted to be an attribute of what is referred to by that name.

e.g. This object is round. (Rawson, 1969:17)

### General Propositions

General propositions are statements which mention the members of a class and the class to which the members belong. The general proposition is comprised of two parts, the name of a class and the name of the class that also includes the other class.

e.g. The O's are counters. F C G (Rawson, 1969:18)

### Singular Terms

Singular terms are expressions that function as subjects in the singular propositions.

e.g. This object is red. (The singular term is "object.")

### General Terms

General terms are the predicates in general propositions.

e.g. Ducks are birds. (The general term here is "birds.")

### Extension of a Class

"Extension of a class is the range of applicability of a decision rule which specifies membership in a class" (Rawson, 1969: 133). In addition the extension of a class can be viewed as the list of members of the class. The extension of a class ducks is all the birds that are assigned the criterial properties of ducks.

### Intension of a Class

Intension of a class is defined by the criterial properties which are common to the members of a class, and also the properties which differentiate the members of a class from other classes (Piaget and Inhelder, 1964:17).

## Class Inclusion

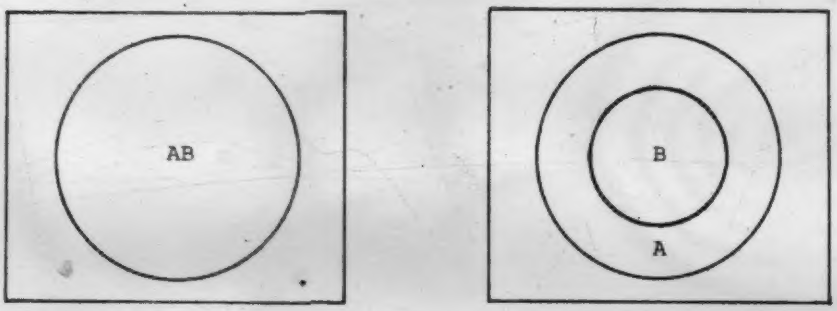
Class inclusion is the relationship between the extension of classes.

$$A \subset B \equiv (x) : (x \epsilon A) \supset (x \epsilon B)$$

A is a subset of B is equivalent to, (if x is a member of A then x is a member of B) (Rawson, 1969:134).

## Complete Class Inclusion

Complete class inclusion is the relationship in which all the members (B) of one class are also members of a second class (A). This relationship may be coextensive or not coextensive.



Every A is a B

Every B is an A

A and B are coextensive

$(A \subseteq B)$

Every B is an A

Every A is not a B

A and B are not coextensive

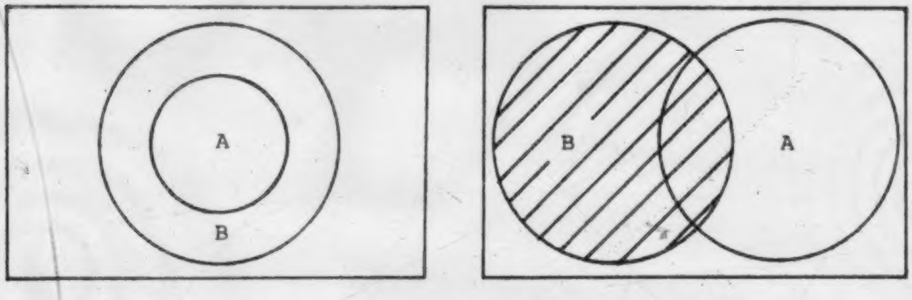
$(B \subset A)$

Figure 1

Complete Class Inclusion and Coextensive and
Not Coextensive Relations
(Rawson, 1969:135)

## Partial Class Inclusion

There are two possibilities for partial class inclusion (B).



Every A is a B

Not every B is an A

At least one B is an A

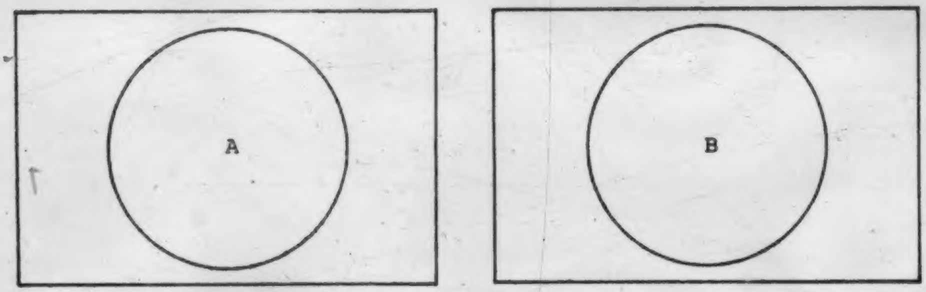
At least one B is not an A

Figure 2

Partial Class Inclusion
(Rawson, 1969:136)

## Complete Class Exclusion

None of the members of (A) are members of (B).



No A is a B

No B is an A

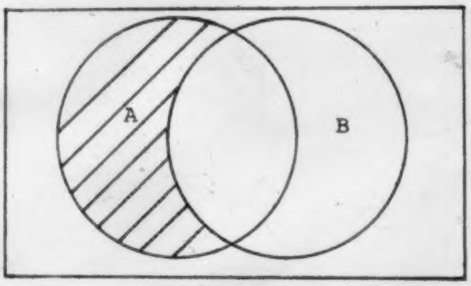
$x = (x \epsilon A) \supset \overline{(x \epsilon B)}$

Figure 3

Complete Class Exclusion
(Rawson, 1969:136)

Partial Class Exclusion

Some members of a class (A) are not members of a second class (B). "There are some x (at least one) such that x is a member of A and it is not the case that x is a member of B" (Rawson, 1969:137).



Some A's are not B's

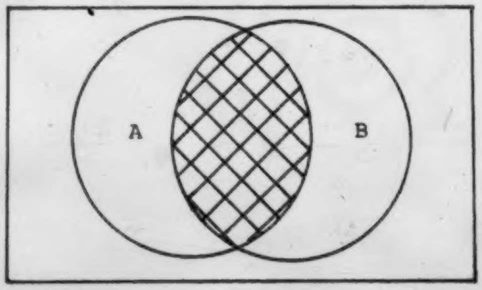
$(\exists x):(x \epsilon A)\ \&\ \overline{(x \epsilon B)}$

Figure 4

Partial Class Exclusion
(Rawson, 1969:137)

Joint Class Inclusion

The extension of two classes overlap so that some A's are B's and some B's are A's.



Some A's are B's

Some B's are A's

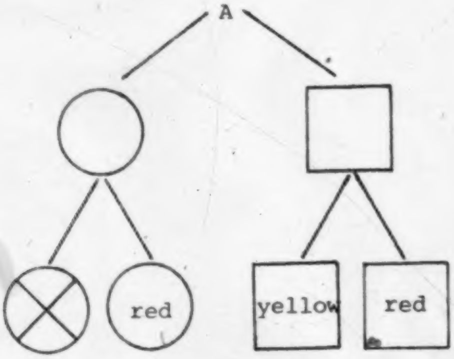
$(\exists x):(x \epsilon A)\ \&\ (x \epsilon B)$

Figure 5

Joint Class Inclusion
(Rawson, 1969:138)

Empty Class

An empty class is a class that has no members.



$$(x):(x \notin A)$$

"For every x, (x), x is not a member of A" (Rawson, 1969:137).

Figure 6

Empty Class

Complementary Class

A complementary class "is the class each of whose members is the negation of a member of its related class" (Rawson, 1969:139).

$$\hat{F}(x) \supset -\hat{F}(-x)$$

If x is a member of the class F then -x is a member of the class -F.

e.g. Dogs and other animals (animals that are not dogs).

A complementary class is usually referred to by the word "other." The word "other" is then followed by the superordinate class to which the other two classes belong. For instance, in the example above, dogs (F) and other animals (-F) are members of the superordinate class animals.

## RESEARCH QUESTIONS AND HYPOTHESES

Four research questions and hypotheses arise from the previous discussion and will now be presented.

| | Classification | | | |
|---|---|---|---|---|
| | Additive | | Multiplicative | |
| | Concrete | Reading | Concrete | Reading |
| More Proficient Readers (MPR) | A<br>(CA) | B<br>(RA) | C<br>(CM) | D<br>(RM) |
| Less Proficient Readers (LPR) | E<br>(CA) | F<br>(RA) | G<br>(CM) | H<br>(RM) |

Figure 7

Basic Design of the Study

Research Question 1

Will the mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification not be significantly different? (A,E)

Hypothesis 1

The mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification will not be significantly different. (A,E) (Level of significance, p greater than .01)

Research Question 2

In the additive reading tasks of classification, will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers? (B,F)

Hypothesis 2

In the additive reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient reader. (B,F) (Level of significance, p less than .01)

Research Question 3

Will the mean performance of the more proficient and the less proficient readers, in the multiplicative concrete tasks of classification, not be significantly different? (C,G)

Hypothesis 3

The mean performances of the more proficient and the less proficient readers, in the multiplicative concrete tasks of classification, will not be significantly different. (C,G) (Level of significance, p greater than .01)

Research Question 4

In the multiplicative reading tasks of classification, will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers? (D,H)

Hypothesis 4

In the multiplicative reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers. (D,H) (Level of significance, p less than .01)

## PROCEDURES

The present investigation was conducted in six major parts:

1. The selection of 219 grade six students.

2. The administration of the initial test instruments, New Developmental Reading Tests, Bond, Balow and Hoyt, 1968.

3. Analysis of this data, and the establishment of a criterion to select and identify more and less proficient readers.

4. Construction of additional test items and stories and the piloting of the total instrument on a random sample of five more proficient and five less proficient readers.

5. Revision of test items, and development of exploratory criteria to analyze and score responses.

6. Selection of statistical tests and the analysis of the data on the basis of these tests.

## LIMITATIONS OF THE STUDY

The theoretical stance assumed in this study rests on Piaget's view of cognitive development, hence the limitations and assumptions of Piaget's view of cognitive development will also be applicable to this study. Furthermore the analysis of Rawson's (1969) initial findings, e.g. the relationship between classification in a concrete situation and the classification in a reading situation, were not considered significant at the α.05 level. However the methodological rigor, and the theoretical viewpoint assumed by Rawson (1969) suggest the need for the development and possible refinement of the instruments and administration procedure used in the initial study.

In addition a number of more specific limitations are also evident:

1. The operations and specific criteria of classification are interrelated, hence the two primary aspects of classification, additive and multiplicative classification, may also be somewhat interrelated.

2. The Piagetian operations or criterion of classification outlined in this section are of a descriptive nature. Furthermore, the psychological reality of these operations is still speculative.

3. Due to the nature of the reading act the two classification tasks, concrete and reading, may not be completely equivalent.

4. The view of reading comprehension proposed in the study rests on Hunkins' Taxonomy (Hunkins, 1976:19-22) and Smith and Barrett's (1974:52-58) view of reading comprehension. This view is general in nature, and may require further refinement.

## OVERVIEW OF THE STUDY

The logical operations of classification in both a reading and a concrete situation were assessed in a population of 20 more proficient and 20 less proficient readers. These 40 subjects were selected from a population of 219 grade six students. All subjects in the population had been previously assessed in terms of two major screening instruments, New Developmental Reading Test Intermediate Level and the Canadian Lorge Thorndike Intelligence Test.

## ORGANIZATION OF THE REPORT

This research investigation will be presented according to the following plan:

Chapter II presents a discussion of the literature and research related to the Piagetian notion of additive and multiplication classification.

Chapter III presents a review of the literature related to the problem to be investigated.

Chapter IV discusses the experimental design of the study and Chapter V discusses the main test instrument used in the study.

Chapter VI presents a discussion of the analysis of the data and the results.

Chapter VII, the final chapter, presents and discusses the main findings, conclusions and implications of the study.

# CHAPTER II

## PIAGETIAN CLASSIFICATION AND SUPPORTING RESEARCH

This chapter will review the Piagetian notion of classification. It was felt by the researcher that since the literature related to the Piagetian concept of classification was scattered and not readily available to the professional layperson, a review of the Piagetian stance and related research would be appropriate. The more direct relationship between the operations of classification and reading comprehension will be discussed in Chapter III. To be included in this chapter is a discussion of the origin and development of the operations of classification. The descriptive procedure utilized by Piaget and Inhelder (1964) to describe the operations of classification will also be discussed. The operations of classification will be described both in terms of Piaget and Inhelder's (1964) and Rawson's (1969) viewpoint. A review of the more recent research related to additive and multiplicative classification will follow.

## ORIGIN OF CLASSIFICATION

The operations of classification are an essential component of thought, and since thought is an essential component of reading comprehension, the operations of classification are also a primary component of reading comprehension. These operations have an origin and place in the cognitive development of the child. The extent to which these operations are developed is a factor contingent upon whether the child has access to these operations in reading comprehension.

In general, classification can be viewed as the operation of putting together what belongs together by virtue of a property abstracted from and common to all the members.

Piaget and Inhelder (1964:2-16) discuss three possible views of the origin of the operations of classification. Initially language could be viewed as the basis for the origin of classification, primarily because syntax and the semantics of language involve the structures of classification. However as they suggest and the findings of Furth (1966:143) further suggest, the deaf individual can carry out essentially the same operations in classification as the non-deaf individual. There is however a slight retardation in the non-hearing individual's handling of the more complex modes of classification (Piaget and Inhelder, 1964:3). Piaget and Inhelder (1964:3) continue and point out that even though children speak the language, this does not mean that the logical operations have been assimilated along with the linguistic forms. In essence, the nature of the language learned is a function of the child's level of development. For instance, the fact that a child calls a dog "a dog" does not prove that he understands the class of dog.

Essentially, before a child can understand the implicit operations of classification and apply them, there must be a restructuring and further development of the mental operations involved. This restructuring can be accelerated by language and language can perform a useful role in completing this development. However according to Piaget and Inhelder (1964:4) language is a sufficient but not a necessary condition of this development.

A second viewpoint regarding the origin of the operations of classification is maturational. This view suggests that the child is not able to acquire the operations of classification until the nervous system and other biological factors are developed. This being primarily reductionist, does not take into consideration that development is dependent upon the interaction between the child's acquired experiences and the environment. As Piaget and Inhelder (1964:5) suggest, the development of the logical operations of classification demand both the action of the practice and acquired experience, and also the influence of a favorable social environment.

However, as Piaget and Inhelder (1964:5) suggest, if the origins of the operations of classification cannot be attributed to solely maturational and language factors, then the origin of these operations must lie in the sensori motor, preoperational and perceptual structures. This is suggested by the findings that long before children classify objects they can perceive the objects in terms of relations of similarity and differences. However this view will only hold if one defines perception (visual and haptic) as being interrelated with the schemas and operations of a higher order, and thus these schemas and operations can influence perception (Piaget and Inhelder, 1964:7).

In conclusion, Piaget and Inhelder (1964:13) note that the origins of classification are to be found in the sensori motor schemata as a whole and that perceptual schemata form an integral part of the whole. This view of the origin of the operations of classification will ultimately determine one's definition of classification and one's criteria for the operational existence of classes.

Essentially, in examining the presence or absence of the operation of classification in both the reading and concrete situations, a total language basis cannot be assumed, since the logical thought of the child must also be considered. Furthermore, this suggests that even if children may use language (that may indicate the use of these operations) children may still not be able to use these operations in logical thought.

## DESCRIPTION AND PROPERTIES OF A CLASS

An attempt will be made in this section to provide a more clear and precise description of the operational existence of classes. This is essential, since one's description of classes will ultimately affect how one views and describes the presence or absence of classes and the operations of classification in a reading and concrete situation.

Principally, a class involves two kinds of properties and relations. These are the intensive and extensive properties (Piaget and Inhelder, 1964:7). The intensive properties of a class are the properties that are common to the members of the class, in addition to the set of differences which distinguished the class from other classes (Piaget and Inhelder, 1964:7). The extension of a class is defined as the set of members comprising the class (Piaget and Inhelder, 1964:8).

In addition, Piaget and Inhelder (1964:7-8) outline the following criteria to define the operational existence of classes:

1. *Complementarity* is defined as the sum of the difference between two classes $A$ and $A'$ and where the two classes are also similar by virtue of their common membership with $B$.

e.g. Vegetables are living things, which are not animal.
In this case non animal is the complementarity.

2. *Relations of resemblance* are all the properties that are common to the elements of one class.

3. A class can be defined by both *genus* and *specific differences*; thus class membership can be defined by the property $b$ and $a$ or both $b'$ and $a'$.

4. *Intensive quantification* is indicated by the use of quantifiers "all, some, and none."

5. *Class inclusion* must satisfy the following propositions: all $A$ are some $B$, and $A$ is less than $B$, $(A < B)$.

6. The *relation of class membership* is the relationship between the element $x$ and the class $A$ to which $x$ belongs $(x \varepsilon A)$.

These propositions can more generally be viewed and summarized as:

1. No object is a member of both classes simultaneously. (Note this is distinct from intersect.)

2. All the members of a class share some similarity or defining property. This is known as the intension of a class (Ginsberg and Opper, 1969:121).

3. All classes may be described in terms of a list of its members, or the extension of the class.

4. The defining property of a class determines what objects

are placed in it. Another way of stating this is intension defines extension (Ginsberg and Opper, 1969:121).

The view that intension defines extension and the gradual differentiation and progressive co-ordination of extension and intension on the part of the child, is considered by Piaget and Inhelder (1964:17) to be the most central and principal problem in the development of a mature concept of classification. Children are normally 9-10 years of age before this distinction is made (Piaget and Inhelder, 1964:7).

## THE STAGES OF DEVELOPMENT OF CLASSIFICATION AND PIAGETIAN DESCRIPTION OF THE OPERATION OF CLASSIFICATION

This movement towards a mature concept of classification on the part of the child follows three distinct stages of development.

The first stage, usually extends from the age of 2 to 5. In this stage the child does not tend to organize material into hierarchical classes and subclasses founded upon similarities and differences of the objects, but rather classifies the material into complex objects or figural collections (Flavell, 1963:304). Piaget and Inhelder (1964:17) refer to these as graphic collections. The alignments formed during this stage are not classes because intension does not define extension and no defining property is used as a basis for classification. Furthermore, the child does not operate under an overall plan (i.e. a system of rules) and organize the way in which the objects are arranged (Ginnsberg and Opper, 1969:122).

During stage two, age 5 to 7, the child can produce collections which seem to be real classes, and the child can organize them in a hierarchical manner (Ginnsberg and Opper, 1969:125). According to Piaget and Inhelder (1964:48) this form of classification can be described according to the following operational criteria of additive classification:

1. All the elements are classified and accounted for. $(X) \varepsilon A$.

2. There are no isolated classes. For instance, every specific class A is characterized by the property a, and implies its complement not A ($A'$).

3. The class A will include all members having property a.

4. The class A will only include members having the property a.

5. All classes of the same rank will be disjoint. $A \times A' = 0$ (A cannot be A and not A at the same time).

6. The complementary class $A'$ will have the characteristics $a_x (A' = A_x)$. These characteristics are not possessed by its complement A.

7. The class A (or $A'$) will be included in the higher ranking B. This higher ranking class B will include all the elements of A. (All A are some B.)

$$A = B - A', \; B = A + A', \; A' = B - A$$

(This operation is not readily applied until the very later part of stage two.) (Piaget and Inhelder, 1964:50)

8. Extensional simplicity. The inclusions in the classes constructed are reduced to a minimum. i.e. The subject makes the fewest piles or classes possible.

9. Intensional simplicity. The attributes of the elements classified are reduced to as few as possible, to distinguish classes of the same rank.

10. Symmetrical subdivision. In this case if the class B is segmented into $A_1$ and $A'_1$ and the same criteria are applicable to $B_2$, then $B_2$ must also be divided into $A_2$ and $A'_2$ (Piaget and Inhelder, 1964:48).

However, at this level the child does not yet understand or comprehend the different levels of the hierarchical classification. Essentially, the child can form collections but does not understand class inclusion. Furthermore, because the child centers on the parts and ignores the whole, intension and extension are not yet interrelated. This is indicated by the child's difficulty in understanding the two operations of quantification which involve the words "all" and "some." These are:

1. "All the A's are some of the B's

2. All the A's are B's and some of the B's are A's, therefore B includes A

3. B - A = A′ (since A + A′ = B)" (Rawson, 1965:50).

According to Piaget and Inhelder (1964:158), children are able to use these terms quite freely in their language but fail to understand the meaning of these words.

During stage three, age 7 to 11, the child is capable of both constructing hierarchical classifications and comprehending inclusion. He is able to classify using two or more criteria simultaneously, and thus form matrices or multiplicative classes (Ginsberg and Opper, 1969:127). During this stage the child is also able to form and define intersections between classes (Piaget and Inhelder, 1964:177).

More specifically, the ten criteria of additive classification continue to apply; however, every one of these criteria apply equally as well to multiplicative classification. This is primarily due to the operation of multiplication being composed of two or more additive classifications. However, to account for the new operations, Piaget and Inhelder (1964:152-153) add four new criteria to the former list of ten.

11. All the components of $B_1$ belong to $B_2$. This is also applied vice versa, thus if $B_1 = A_1 + A'_1$

$$B_2 = A_2 + A'_2$$

then $B_1 \times B_2 = A_1A_2 + A'_1 A'_2 + A'_1 A_2 + A_1 A'_2 = B_1B_2$.

12. All the components of $A_1$ must belong either to $A_2$ or $A'_2$. However if the components of $A_1$ belong to both $A_2$ or $A'_2$ then $A_2 \times A'_2 = 0$.

13. The classes $A_1$ and $A'_1$ contain only elements belonging either to $A_2$ or to $A'_2$. The same is true vice versa.

14. Each of the associations of $A_1A_2$ and $A'_1 A'_2$ et cetera comprise one and only one multiplicative class.

Even though the intensive and extensive class properties are fully integrated during this stage the child is still functioning at a concrete level of operations. However, by the age of 11 to 12, the child no longer requires the members of a class to be familiar to him. The child can now apply these operations to new and unfamiliar structures (Rawson, 1965:59).

This gradual development of the operations of classification is of primary importance to reading comprehension. Essentially, to comprehend some reading material may require the use of or reliance on the operations of classification. However, as the discussion of the development of classification suggests, the child may not have access to all these operations until the age of 11, even with the use of concrete props and familiar items. This suggests that readers before the age of 11 may have difficulty with these operations in a reading context, primarily because the operations are not as yet fully operational.

## THE PIAGETIAN DESCRIPTION OF CLASSIFICATION

The description and criteria that Piaget relies on to describe the child's achievement during these three stages originate from Piaget's view of a logical mathematical model. Piaget suggests that language in general is too imprecise; thus he uses the instruments of logic and mathematics to describe, with precision, what he observed (Piaget and Inhelder, 1969:153). It should be noted that Piaget does not use logic as an explanation of the psychological phenomena themselves but uses it in terms of a "well formed language" and operationalism. Piaget (1957:6) notes that in the use of "operationalism" logic and psychology can meet.

Piaget (1957:8) defines operations as internalized and reversible actions that are coordinated into systems which are characterized by laws that apply to the system as a whole. An operation is internalized since it is carried out in thought as well as executed materially and is reversible since it can take place in any direction as well as in the opposite direction (Piaget, 1970:21). An operation is also a transformation, since it is an action. However, it is a transformation that does not transform everything at once, or else there would be no possibility of reversibility (Piaget, 1970:22).

Piaget primarily derives his description of the operations of classification from his eight mathematical groupings which he uses to describe the concrete operations (Flavell, 1977:83, 1963:180). Grouping I, II, III and IV are used to describe the operations of classification while grouping V, VI, VII and VIII are used to describe the operations of seriation (Kretschmer, 1972:18). Since the focus of this study is the operations of classification, only the first four groupings will be discussed.

Grouping I principally refers to the primary addition of classes and the construction of a class hierarchy (Ginsberg and Opper, 1969:134; Kretschmer, 1972:22). For instance, the class of red counters and the class of green counters can be combined to form the superordinate class of counters.

Grouping II is the secondary addition of classes or vicariances. The grouping accounts for the operation of reclassifying the former classes, analagous to and parallel to series, in other groups. A vicariance is characterized by $A + A' = A_2 + A'_2$ (Flavell, 1963: 192). In summary, this grouping is the inclusion of the complements of the classes and subclasses in the established hierarchy. For example, the existence of the class of red counters necessitates existence of its complement, or secondary class, those counters which are not red, and also necessitates the existence of the superordinate class counters.

Grouping III involves the bi-univocal multiplication of classes. This grouping is generally used to describe a square matrix or relation (Flavell, 1963:178). Kretschmer (1972:23) suggests that this exists when a class hierarchy is used to describe class members according to two or more attributes. For instance a set of counters may be simultaneously classified according to color, shape and size.

Grouping IV involves the co-univocal multiplication of classes. This involves the multiplication of one class, with several members of each of one or more additional classes. The grouping properties of this grouping are identical to grouping III, and are primarily used to describe the generating of a triangular matrix or intersect (Flavell, 1963:179). Essentially, a class of red and green counters may be the intersect of a class of red and yellow counters and green and blue counters.

## RAWSON'S DESCRIPTION OF THE OPERATION OF CLASSIFICATION

Rawson (1969) devised a criterion of classification in terms of nine specific operations. These are based on the viewpoints of Piaget and Inhelder (1964:59-99,151-196), Kneale and Kneale (1962:350-351), Langer (1953:140) and Quine (1964:87). The operations are: abstraction, quantification, addition of classes, complement of classes, hierarchical class structure, empty class, predicate operation, multiplication of classes, and matrix class structure. The description of these operations is as follows:

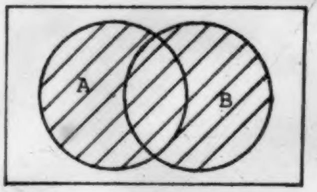
1. Abstraction ($\hat{x}$) is defined as the operation by which given the condition "f" upon "x" the class "$\hat{x}$" is formed. The class "$\hat{x}$" is only comprised of those members which satisfy the condition "f" (Quine, 1964:87). Abstraction is also the operation by which a class name is formed from a predicate.

e.g. Birds are feathered animals. All the x (animals) satisfy the condition f (feathers) to form the class $\hat{x}$ (birds).

$$(\hat{x})\ f(x) \quad \text{(Rawson, 1969:148)}$$

2. Operation of Quantification involves the use and understanding of the terms "all," "every," $(x)$; "some" $(\exists x)$; "more" $(>)$ and "no," "not any" $(\sim\exists x)$. These describe the relations between the extension of classes (Rawson, 1969:149; Kneale and Kneale, 1962: 350-351).

3. Operation of Addition of Classes (&) is the process by which a new class is constructed by including in the new class, members of other classes (Rawson, 1969:151; Langer, 1953:140).



K = (A & B)

e.g.

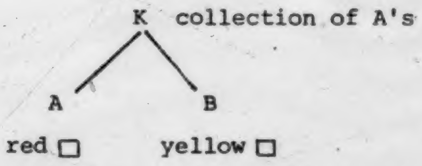


Figure 8
Addition of Classes

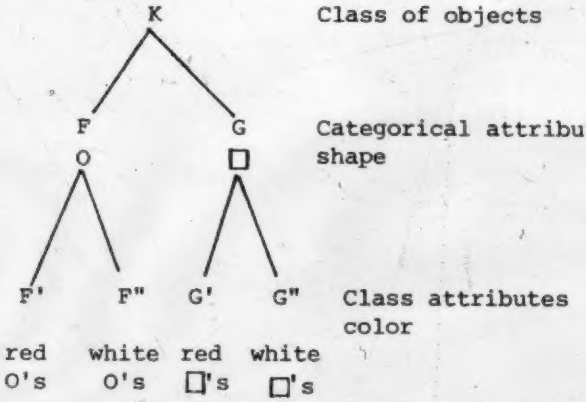
The class "K" only includes members which belong to at least one of the classes A and B.

4. Operation Complement of a Class (-) is the procedure through which a new class is constructed which is the negation of the given class (Rawson, 1969:152).

e.g. The complement of the class pintails (A) would be the class other ducks (-A). These two classes when added together would form the class ducks (D).

5. "Operation Hierarchical" Class Structure "is the procedure for ordering classes in a superordinate-subordinate relation in which certain additive and disjunctive relations between the classes hold true" (Rawson, 1969:153).

$$(x):(x\varepsilon K) \supset (x\varepsilon F) \vee (x\varepsilon G)$$


K
Class of objects
F
G
Categorical attributes
shape
O
□
F'
F"
G'
G"
Class attributes
color
red
O's
white
O's
red
□'s
white
□'s

$$\hat{K} = \hat{F} + \hat{G}$$

$$\hat{G} = \hat{K} - \hat{F}$$

$$\hat{F} = \hat{K} - \hat{G}$$

Figure 9

Hierarchical Class Structure
(Rawson, 1969:153)

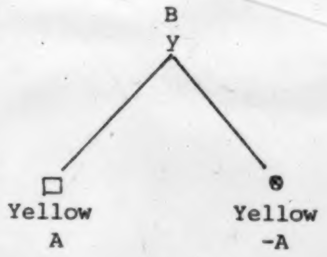
6. Operation Empty Class (⊗) is the procedure involved in establishing a new class, which has no members, and is itself a member of another class (Rawson, 1969:152).

e.g. The subject is presented with classes of 10 red rounds, 3 yellow rounds, 3 red squares, and 3 yellow squares. Three groups of counters are all covered, and the yellow rounds are removed, but left in view.

Question: I am going to give you a yellow one from what is left. Will it have to be square? Why is that?

The response can be described in the following manner:

$$\hat{X}y = \hat{X}\overset{\text{Yellow}}{\square} + \hat{X}\overset{\text{Yellow}}{\otimes}$$



$B = A + (-A)$

Figure 10

Empty Class
(Rawson, 1969:158)

7. Predicate Operation is the procedure by which a proposition is formed from a name. This can involve individual or class names (Rawson, 1969:148)

e.g. ΨX These counters (X) are all red ones (Ψ).

e.g. ØΨ Red Heads are diving ducks (Ø).

8. Operation Multiplication of Classes (x) is the procedure involved in constructing a new class which is the "logical product" or the common part of two classes (Rawson, 1969:152).

9. Operation Matrix Class Structure is the procedure by which multiplicative classes are ordered to form a matrix (Rawson, 1969:154).

e.g.

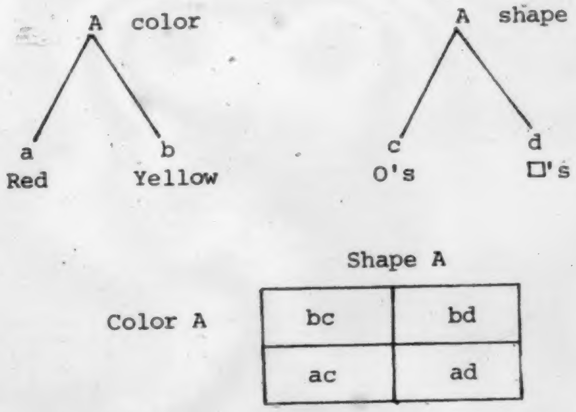


Figure 11

Matrix Class Structure

Principally, because the operations of classification are not in isolation of each, they can be viewed in terms of four major dimensions: (1) abstraction and membership in a class (operations of abstraction), (2) inferring class inclusion relations (operations of: quantification, empty class, hierarchical class structure, complement of a class, and addition), (3) constructing predicates which describe the extension of dichotomous classes (predicate operation), and (4) constructing and ordering multiplicative classes (operation matrix class structure, multiplication of classes). However, it should be noted that some of the operations described by Rawson (1969:154) may be included in more than one dimension, thus the dimensions are not considered to be mutually exclusive.

In reference to the previous criterion established by Piaget and Inhelder (1964:48,152-153), criteria 1 through 10 (see pages 28-29) would be included in the dimensions, abstraction and membership in a class, class inclusion relations, and the construction of predicate, and criteria 11 through 14 would be included in the dimension mutliplicative classes and relations. Criteria 1 through 10 would also correspond to groupings I and II, and criteria 11 through 14 would correspond to groupings III and IV.

Piaget states that logical operations cannot be viewed or assessed independently, and in isolation of each other. This view was accepted in this study and the operations of classification were viewed in terms of five major dimensions.

The first three corresponded directly to the dimensions devised by Rawson (1969:154). The last two (matrix classification and intersection) are subsets of Rawson's fourth dimension; multiplicative classes and relations. The five dimensions are as follows:

I. Construction of Classes
II. Class Inclusion
III. Predication (the construction of dichotomous classes)
IV. Matrix Structure
V. Intersection.

These dimensions are primarily used for descriptive purposes. Dimensions I through III were combined to form the aspect additive classification and dimensions IV through V were included in the aspect multiplicative classification. These two aspects are located as the dependent variables in this study.

## RESEARCH RELATED TO ADDITIVE CLASSIFICATION

In this section a brief review of the literature related to the development of the operations of additive classification will be presented. This is of primary importance to reading comprehension since an assessment of the nature of the development of the operations of classification in a nonreading situation may provide some valuable insights into how these operations may develop in reading comprehension and thought.

Kofsky (1968:211), in a study involving 122 children aged 4 to 9, attempted to assess the validity of the stages of classification devised by Piaget and Inhelder (1964:285). More specifically, Kofsky attempted to assess whether the order of difficulty of the devised classification tasks would correspond to the developmental sequence described by Piaget and Inhelder (1964:48-49,152-153). Furthermore, Kofsky (1968:212) attempted to assess the extent to which the subjects (who had acquired a particular level of classification) had also mastered all the preceeding levels. The developmental scale Kofsky (1968:211-212) derived, consisted of two related groups of experiences. The first group of experiences were: resemblance sorting, consistent sorting, exhaustive classes, conservation, multiple class membership, horizontal reclassification, and hierarchical reclassification.

Resemblance sorting can be identified when the child groups together two objects that are equivalent on the basis of a primary visual attribute. Consistent sorting begins to occur when the child can extend the sorting to more than two objects. In exhaustive sorting, the child can extend the scope of his sorting to all the objects that he would consider equivalent. As he begins to conserve, he discovers that existing classes are transitory and spatial proximity becomes a less favorable means for categorizing. With the discovery of multiple class membership, the child can recognize that objects can belong to many classes. In horizontal classification, the child actively attempts different groupings of objects. At this point he is able to systematically choose one attribute, and then is able to rely on another single attribute, as a focus for grouping. Finally with the advent of hierarchical classification, he is able to choose single attributes and then combinations of attributes to construct successive classes.

The second group of related experiences are knowledge of "some" and "all," class addition ($A + A'$), class subdivision ($B - A'$) and part whole inclusion ($B > A$) (Kofsky, 1968:212). As the child understands the meaning of the quantifiers "some" and "all" he can describe the extent to which classes overlap. With the development of class addition he can join subclasses to form a superordinate class, and with the development of class subdivision he can divide superordinate classes into constituent parts. Finally, with the advent of part whole inclusion, he can keep in mind the logical relationship between the subclass and the whole superordinate class (Kofsky, 1968: 212).

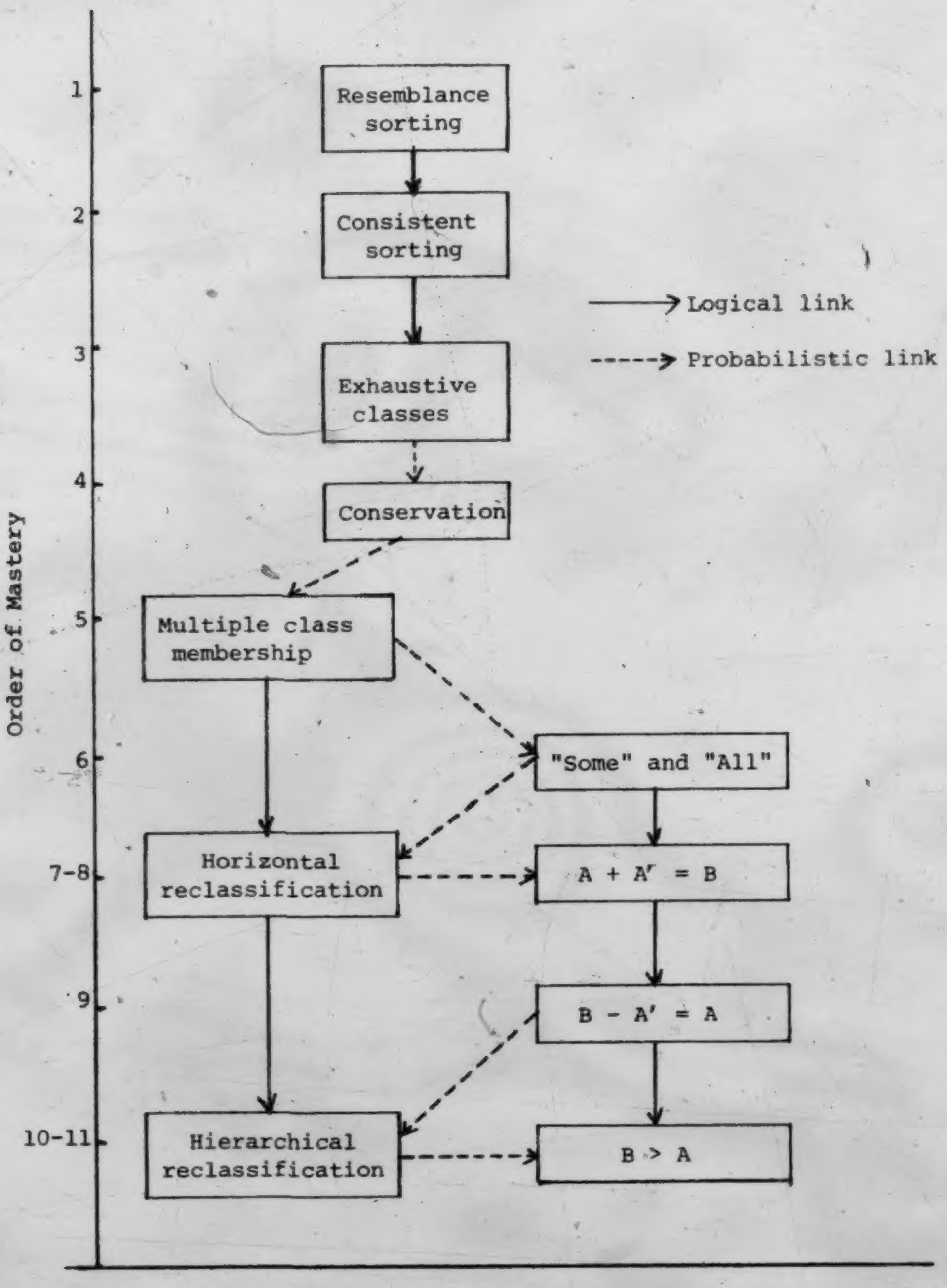

Order of Mastery
1
2
3
4
5
6
7-8
9
10-11
Resemblance sorting
Consistent sorting
Exhaustive classes
Conservation
Multiple class membership
Horizontal reclassification
Hierarchical reclassification
"Some" and "All"
A + A′ = B
B − A′ = A
B > A
Logical link
Probabilistic link

Figure 12

A Sequence of Classificatory Skill Development
(Kofsky, 1968:213)

The analysis of the findings indicate that the 9 year olds performed better than the 7 and 8 year olds, and the 7 and 8 year old subjects performed better than the younger subjects (Kofsky, 1968:218).

Ahr and Youniss (1970:132), in a study of the operation of classification and class inclusion amongst 60 children age 6 to 10, presented two tasks: one with pictures of pets as a superordinate class and the other with pictures of flowers as the superordinate class. The 60 subjects were divided in terms of age. The final outcome was three groups of boys aged 6 years 5 months, 8 years 5 months and 10 years 5 months and three groups of girls of the same age classification. Each member of these groups was then presented with ten class inclusion problems (Ahr and Youniss, 1970: 133). Ahr and Youniss (1970:134) found that the older students, 10 years 5 months, averaged between five and seven correct answers, while the younger subjects ages 8 years 5 months and 6 years 5 months averaged between two and one correct responses. Ahr and Youniss (1970:141) also found that subjects tended to perform better if the class inclusion question was comprised of all three classes (the superordinate classes (B) and the subordinate classes (A, A′)) rather than only the two classes, superordinate (B) and subordinate classes (A).

Piaget and Inhelder (1964:101), in an attempt to further assess the qualitative nature of the development of class inclusion and hierarchical classification, presented 20 pictures (four representing coloured objects and 16 representing flowers) to 69 subjects, aged 5 to 10. Of the 16 pictures of flowers, eight were primulas, of which four were yellow and the others were of different colors. The classes can be represented by the following:

A (yellow primulas) < B (primulas) < C (flowers) < D (flowers and other objects).

The tasks presented to the subjects were comprised of three general areas:

1. Spontaneous classification
2. General question or inclusion
3. Four types of questions all bearing on the quantification of inclusion (Piaget and Inhelder, 1964:101).

The assessment of the results indicates that the older subjects performed consistently better than the younger subjects. There was also a consistent improvement in performance with age on the general inclusions questions, and the four types of questions involving the quantification of inclusion (Piaget and Inhelder, 1964:103).

Table 1

Percentage of Correct Answers to Questions on the General Inclusion of Classes for 69 Children, 5-10 Years of Age

| | Age | | | |
|---|---|---|---|---|
| | 5-6 (20)* | 7 (19) | 8 (17) | 9-10 (13) |
| Percentage of Success | 24 | 26 | 61 | 73 |

* Number in brackets refers to the number of subjects in the age group.

However, insufficient numerical data were given that would support the contention that there was improvement with age on the four types of questions involving the quantification of inclusion. Nevertheless, the general findings support the previous findings of a study conducted by Piaget and Inhelder (1964:89). In this study 86 children, ages 5 to 9, were tested to assess their knowledge and use of the quantifiers "all" and "some." In the quantification of inclusion, the children were presented with groups of counters, and asked four questions concerning the nature of the class inclusion. These questions primarily involved the use of the quantifier "all" (Piaget and Inhelder, 1964:89).

Each child was presented with 8 to 21 red squares and blue circles, and asked the following questions:

1. "CB: Are all the circles blue?
2. RS: Are all the red ones square?
3. BC: Are all the blue ones circles?
4. SR: Are all the squares red?" (Piaget and Inhelder, 1964:63).

Table 2

Percentage of Correct Answers to the Four Questions CB, RS, BC, and SR

| Age | CB | RS | BC | SR |
|---|---|---|---|---|
| 5 (23)* | 82 | 57 | 69 | 70 |
| 6 (31) | 63 | 58 | 60 | 79 |
| 7 (14) | 64 | 68 | 73 | 88 |
| 8 (10) | 80 | 90 | 85 | 95 |
| 9 (8) | 81 | 81 | 81 | 100 |

*Number in brackets refers to the number of subjects in the age group.

The general assessment of performance suggests a gradual improvement with age in the understanding of the quantifiers "all" and "some," and the quantification of inclusion. In the analysis of the children's performance, Piaget suggests a number of reasons that could possibly account for the children's difficulty with class inclusion.

1. Children at stages I, II and the initial period of stage III find it difficult to adjust their use of "all" and "some" to the intensive properties of the elements to which these quantifiers are being applied (Piaget and Inhelder, 1964:59). More operantly, "all" may be confused with "many" and "some" may be confused with "few" (Blackford, 1970:20).

2. The operation $B = A + A'$ is not fully reversible, $(A + A' = B) \longleftrightarrow (B - A' = A)$; thus as soon as A and A′ are separated in thought, the child loses sight of B, and only compares A and A′. In essence, the child cannot deal with the whole and the parts simultaneously (Piaget and Inhelder, 1964:103; Blackford, 1970:25; Wilkinson, 1976:65).

Once the child has achieved a clear differentiation and understanding of "some" and "all," the concept of reversibility in the operation $(A + A' = B) \longleftrightarrow (B - A' = A)$ and the relation $(B > A)$ then the concept of class inclusion becomes totally operational in additive classification (Blackford, 1970:25; Piaget and Inhelder, 1964:118).

As the child's thinking in classification becomes more operational, the child becomes more flexible in selecting and relying on different criteria of classification. In another study by Piaget and Inhelder (1964:208), 60 subjects aged 5 to 9 were presented with cardboard cut-outs differing in color, shape and size. The subjects were asked to classify the cut-outs into two groups. The subjects (who were able to classify the objects using the criterion correctly) were asked to reclassify the cut-outs a second way and then a third way. Table 3 shows the number of criteria discovered by the subjects.

Table 3

Number of Criteria at Ages 5-9

| | Age | | | |
|---|---|---|---|---|
| Criteria | 5<br>(12)*<br>% | 6<br>(17)<br>% | 7<br>(18)<br>% | 8-9<br>(13)<br>% |
| 0 | 27 | 12 | 5 | 0 |
| 1 | 46 | 12 | 11 | 0 |
| 2 | 27 | 47 | 56 | 31 |
| 3 | 0 | 29 | 28 | 69 |
| 2 or 3 | 27 | 76 | 84 | 100 |

*Number in brackets refers to the number of subjects in age group.

(Piaget and Inhelder, 1964:209)

The assessment of the findings suggest that the older children tend to be more flexible in their application and use of different criteria for classification. This increased flexibility of the older child is due to the child being more able to directly pick out the most general characteristics of the stimulus objects presented to him, and then divide the objects into the major classes. In this case the extension is maximal and the intension is minimal. The child is also more able to rely on the strategy of anticipation and discover several dichotomies (Piaget and Inhelder, 1964:213). This increased ability to discover several complete dichotomies is an essential preparatory strategy for cross-multiplication and the further development of the multiplicative schema (Piaget and Inhelder, 1964:209).

Fenker and Tees (1976:340) attempted to assess the extent to which children's ability to classify stimulus objects was affected by the total number of stimulus items the children had to classify. Sixty children, ranging in age from 4 years 11 months to 6 years 11 months, were presented with a sorting task and a similarity task. In the similarity task the child was presented with a series of pages of pictures containing four sets of three items. The child was asked to draw lines to similar items in each triad, and place an "X" over the ones that were different (Fenker and Tees, 1976:342). In the sorting task 27 item-pictures were presented simultaneously, and the child was requested to group the items into nine circles, given three at a time (Fenker and Tees, 1976:343). The analysis of the findings suggest that the sorting task was clearly more difficult for the 60 subjects, than was the similarity task.

Fenker and Tees (1976:343) did not provide any information on the extent to which performances in these two tasks may change with age or development. However their results do suggest that difficulty in classification could be the result of children's inability to deal with the demand characteristics of the classification tasks, as opposed to the inadequate development of the operations of classification.

It appears that Piaget and Inhelder (1964:154) may have attempted to account for this numbers effect by (1) presenting subjects with 16 items or less in free classification tasks, (2) presenting subjects with items that the subjects were familiar with and (3) providing explicit directions. Through explicit directions the subjects were provided with some procedural constraints.

Robinson (1975:83), in a study involving 22 children age 62 to 74 months, attempted to assess whether the children (who received training in the formation of superordinate classes) will perform significantly better on the Piagetian quantitative class inclusion tasks than kindergarten children who did not receive this training. The 11 control group subjects learned to perform the union of sets with concrete materials. They also learned to state the corresponding sets. The 11 experimental group subjects were taught to respond correctly to the questions concerning a superordinate class including its subsets. For example, pictures of three sweaters and two pairs of trousers were presented. The corresponding question was: Are there more sweaters or more clothes? (Robinson, 1975:86).

Analysis of the post test performance on the test of quantitative class inclusion indicated that the experimental group performed significantly better than the control group. Robinson's (1975:87) findings lend support to Piaget and Inhelder's contention that there is a correspondence in the development of hierarchical classification and quantitative class inclusion. Robinson (1975:87), however, did not provide data for the total percentage success rate for the experimental and control group; thus a more qualitative and specific interpretation could not be made.

Wilkinson (1976:69) in a study involving 24 girls and 24 boys, aged 4 to 5, presented the subjects with two major class inclusion problems: concept inclusion and percept inclusion. The concept inclusion problem consisted of a problem in which the pattern ($P_1$) identified the subclass (A) and a different pattern ($P_2$) identified the subclass (A′); however the supraclass (B) was not identified.

e.g. "Are there more boys or more children?" (Wilkinson, 1976:69)

In the percept inclusion problem the subclass (A) was also identified by the pattern ($P_1$) and the supraclass (B) was identified by the pattern ($P_2$).

e.g. "Are there more houses that have a door or more houses that have a window?" (Wilkinson, 1976:70)

In this problem the subject was presented with pictures of three houses, two with doors and windows and the third with only a window.

Wilkinson (1976:72) found that subjects tended to perform much better on percept inclusion than on concept inclusion. He suggests that this is primarily due to the child being encouraged, by the nature of the task, to rely on a double counting strategy.

In another study involving the same number of subjects, ages four to five, Wilkinson (1976:79) presented the subjects with four major kinds of class inclusion problems, story, percept, concept, and story-picture combined. The children tended to perform significantly better on the percept problems than concept problems. The children also appeared to find the story problem easier than the concept problem. The subjects' performance on the story picture condition was significantly better than on the concept problems, although the two story conditions did not differ significantly (Wilkinson, 1976:82).

Wilkinson (1976:83) notes that inclusion errors may not be due, as Piaget and Inhelder (1964:118) suggest, to the absence of the fully reversible operation $(A + A' = B) \longleftrightarrow (B - A' = A)$ but may rather be due to the following:

1. The concrete operational child may not have developed the skills in thoroughly searching a problem-space for possible relevant solution strategies.

2. In learning to count the child may be predisposed to only using a single counting strategy, and thus not rely on the double enumeration of patterns to solve the class inclusion problem.

3. The child may be inflexible in the exchange of information between the two cognitive systems; semantic analysis and problem solving (Wilkinson, 1976:83-84).

Wohlwill, in a study involving 20 children of mean age five years eleven months, presented the subjects with two forms of a class inclusion task, a pure verbal form and a pictorial form. In the pure verbal condition the subjects were presented with questions of the type: "Suppose I have six apples and two bananas. Would I have more apples or more fruit? Why do you think that?" (Wohlwill, 1968: 450). In the pictorial condition the subjects were presented with pictures of the classes and asked the corresponding class inclusion question. The following example illustrates the nature of the question: The subject was presented with pictures of six apples and two bananas and asked "Are there more apples or more fruit? Why do you say so?" (Wohlwill, 1968:450). The findings reported indicate that all the children performed higher on the verbal condition as opposed to the pictorial condition.

Wohlwill (1968:453) suspected that these findings could be due to a faulty perceptual set. Essentially, the child tended to translate the class inclusion question into one referring to the two subsets. An attempt was made by Wohlwill (1968:454) to account for this by having the children in a similar study count the number of objects in the superordinate and the majority subclass. Again the performance in the pure verbal form was significantly better than the performance in the pictorial situation.

These findings are contrary to Piaget's (1967:62) view that if children are presented with class inclusion questions in the absence of concrete props, their performance should be lower than if the inclusion questions are presented with the concrete props. Wohlwill (1968:462) attributes this phenomenon to the verbal-facilitation effect. This effect counters a perceptual tendency on the part of young children to translate the class inclusion question into a subset comparison. However, in the purely verbal situation, this perceptual tendency is weakened principally because of the lack of the strong perceptual contrast between the numerically unbalanced subclasses.

However, Winer (1974:224) notes that this difference in performance on the two conditions may be due to the different verbal cues presented to the children in each situation. Seventy-two children, 24 in each of grade two, three and four were each presented with three sets of conditions; verbally elaborate questions, pictorial items only, and verbally elaborate pictorial questions (Winer, 1974: 225). The results reported by Winer (1974:225) indicate that the means of the verbally elaborate pictorial conditions and the means of the purely verbal condition were not significantly different. However, both mean performances were higher than the subject mean performance for the pictorial condition only. The results also indicate that the children in grade four performed significantly better than the second and third grade subjects ($p < .01$) (Winer, 1974:226).

Winer (1974:226) notes that these findings indicate that verbal clues are of greater significance in class inclusion reasoning than pictorial cues. Furthermore the distracting effect of perceptual cues as suggested by the verbal-facilitation effect are of minimal significance and the linguistic cues may be more of a contributing factor in improved class inclusion performance.

## RESEARCH RELATED TO MULTIPLICATIVE CLASSIFICATION

Piaget and Inhelder (1964:156) presented 14, 2 x 2 matrices with three of the four spaces filled in, to a group of 4 to 9 year old children. Each child had to rely on either two or three attributes to correctly complete the matrix. In an attempt to control for a perceptual solution, as opposed to an operational solution, the children were required to justify their responses.

Table 4

Percentage of Success on Matrix Test for Children
Age 4 to 9 Years

|  | Age |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | 4 | 5 | 6 | 7 | 8 | 9 |
| Percentage success | 35 | 55 | 60 | 82 | 75 | 90 |

(Piaget and Inhelder, 1964:158)

Piaget and Inhelder (1964:171) received similar results in multiplicative classification when subjects were requested to spontaneously cross-classify a series of pictorial cards or geometric designs. The procedure specifically involved the following steps:

1. Free classification in which the subject was asked to divide all the stimulus material into groups;

2. The child was requested to divide all the stimulus items into four piles using a box with four compartments;

3. One of the partitions is removed and the subject is requested to make only two piles. Once the subject has formed two classes he is asked to repeat the procedure of classification, and arrive at two different groupings.

4. The partition is replaced, and the subject is requested to form a 2 x 2 matrix (Piaget and Inhelder, 1964:165,167-169).

Piaget and Inhelder (1964:167-169) found that the children's responses could be described in terms of seven major types of reactions:

I. The child groups the stimulus materials into two collections without subclasses and without the change of criterion once the two collections have been constructed.

II. The materials are grouped into four collections; however the simultaneous relationships of the collections are ignored. In principle, the subject distinguishes four classes; however he cannot relate them to one another.

III. Two major collections are formed, and only one collection is divided into subclasses.

IV. This reaction yields two successive dichotomies; however the subject does not recognize the classes formed by the union of the two subclasses.

V. The reaction results in a correct classification; however there is no interaction of the two major criteria because the subject arranges the four subcollections diagonally instead of along the vertical and horizontal axes (Piaget and Inhelder, 1964:170).

VI. The correct solution is reached through trial and error.

VII. Immediate cross classification.

Piaget and Inhelder (1964:169) suggest that the order of development is: first type I and II, second type III, third type IV and V, fourth type VI and finally type VII.

Piaget and Inhelder (1964:177), in an attempt to analyze the development of simple multiplication (intersection), presented a number of subjects ages 5 to 10 with a row of green objects (a pear, a hat, a book, etc.) and a row of leaves of various colors (brown, red, yellow, etc.) at right angles to the first row. An empty space was left at the point where the two rows met, and the

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subject was asked to state what object could be put in the cell. The proportion of children 5 to 10 years of age who achieved correct answers is given in Table 5.

Table 5

Percentage of Correct Answers on Intersection Test for Children 5 to 10 Years of Age

| | Age | | |
|---|---|---|---|
| | 5-6 | 7-8 | 9-10 |
| Percentage Correct | 12.5% | 30.0% | 50.0% |

(Piaget and Inhelder, 1964:184)

Piaget and Inhelder (1964:179-184) in assessing the children's performance in the simple multiplication class suggest the following stages of simple multiplication:

I. The choice matches only one collection.

1. The choice is directly identified with a neighbouring element. (It is a neighbouring element.)

2. The choice is directly identified with another element in one of the rows. (Is one of the elements in one of the collections.)

3. The object selected is not in one of the collections, but is functionally related to the second collection.

4. The object chosen is not present already but it bears some degree of resemblance to the elements of one collection.

5. The object chosen is not present already but it

clearly belongs to one of the two classes.

II. The choice is a simultaneous function of the two collections.

1. The choice consists of two elements; one for each collection.

2. The element chosen represents only one element from each of the collections. The two nearest elements are multiplied.

3. The element chosen represents only one element from each of the collections. Two elements other than the two nearest elements are multiplied.

4. The object chosen is selected in terms of a functional relation, or in terms of a partitive relation within a single object.

5. The chosen element bears some degree of resemblance to the elements of both collections, however only genus is used and not differentia.

6. The chosen element directly represents both collections, and is directly related to both collections (Piaget and Inhelder, 1964:184).

Table 6 represents the relative frequency of type I and type II errors of 5 to 10 year old children.

The performance of the subjects on the multiplicative classification tasks suggests that matrix classification is not as difficult as simple multiplication. This is primarily supported by the 90 percent success rate for the nine year olds in matrix classification and only 50 percent success rate for the same age group in simple multiplication (see Tables 5 and 6).

Table 6

Simple Multiplication of Two Classes:
Results in Percentages

| | Age | | |
|---|---|---|---|
| | 5-6 | 7-8 | 9-10 |
| Choice matches one collection only | 85 | 42.5 | 17.5 |
| Choice matches both collections | 15 | 57 | 82.5 |

(Piaget and Inhelder, 1964:178)

The general assessment of the Piagetian research on additive classification and multiplicative classification tends to suggest that the development of the operations is interrelated. Principally, in assessing the performance of the subjects in the tasks of class inclusion and multiplicative matrices, a similar trend of success related to age is observed (see Tables 1 and 4).

Shantz (1968:243) attempted to assess whether the ability to multiply classes (red and square), logical relations (longer and darker) and spatial relations (above and to the left of) developed in close association. An attempt was also made to assess the extent to which younger children would have more difficulty with the logical operations of classification than older children. The subjects were 24 children at each of three age levels; 7 years six months, 9 years 6 months, and 11 years 6 months ($N = 72$). All the children were within 3 months of the half year. Shantz (1968:250) reports finding a significant correlation among all the tasks for the 7 years 6 months and 9 years 6 months groups ($p < .05$); however for the 11 1/2 year olds the correlation among tasks only approached the lower level of significance ($p < .10$). With regards to age, multiplicative abilities improved significantly between all age groups; however, for the 7 1/2 and 9 1/2 year olds, the mean differences only reached the lower level of significance ($p < .10$) (Shantz, 1968: 250).

Parker, Rieff and Sperr (1971:1781) attempted to assess the effectiveness of the training program in teaching 20, 4 year 6 month, 6 year, and 7 year 6 month children the operation of multiple classification. All the experimental subjects received a pretest, training and a post test. The subjects' performance on the pretest suggested that they were all roughly equivalent in the acquisition of the operation of multiplicative classification. Assessment of the subjects' performance on the post test indicated that the treatment effect for the 7 1/2 year olds was significant. However, the 4 1/2 and 6 year old subjects' performance did not improve significantly (Parker et al., 1971:1788). The findings of Parker et al. (1971:1788) may lend support to the Piagetian view that the transferability and learning of the logical operations of multiplicative classification do not become totally operational until the child is operationally predisposed and prepared to learn the operations.

Findlay (1971:96), in a study involving 96 subjects, attempted to verify Piaget's view that complete multiplication is mastered before partial multiplication. According to Findlay (1971:96), in a task involving complete multiplication, the subject is required to pick from a finite number of alternatives to complete the intersect; while in simple multiplication, the subject is required to make a creative response to complete the intersect. The initial sample of 96 subjects was broken into three age groups; 6, 8 and 10 year olds. These three age groups were then further split to form the finite (complete multiplication) and creative (simple multiplication) groups. Findlay (1970:98) found that subjects aged 8 and 10 performed better on tasks involving complete multiplication than on tasks requiring simple multiplication ($p < .001$). The age 6 subjects had equal difficulty with both tasks. Furthermore, 8 and 10 year old subjects performed significantly better on all the multiplication tasks than the age 6 group.

The analysis of the findings of these studies would lend further support to the Piagetian notion of multiplicative classification.

## SUMMARY

The origins of the operations of classification are to be found in the child's sensori motor and perceptual schemata and developed through three stages. These operations are not fully developed until the verge of formal operations. In an attempt to describe these operations, Piaget relies on a logico mathematical model comprised of four groupings (Flavell, 1963:180). To describe these operations of classification Rawson devised a criterion of classification in terms of nine specific operations. These are based on the viewpoints of Piaget and Inhelder (1964:59-99,151-195), Kneale and Kneale (1962:350-351), Langer (1953:140) and Quine (1964:87).

In addition to discussing the development and nature of the operations of classification, this chapter also discussed a number of studies supporting the Piagetian view of classification.

# CHAPTER III

# READING COMPREHENSION, CLASSIFICATION AND RELATED RESEARCH

This chapter will present a number of traditional approaches used in assessing reading oomprehension. In addition, the theoretical view of reading comprehension assumed in this study and the extent to which the operations of classification are related to this view will also be discussed. A review of researchers supporting this view of reading comprehension will follow. The final sections of this chapter will discuss the nature of concepts and research involving the Piagetian view of classification and reading comprehension.

## APPROACHES TO READING COMPREHENSION

### Six Approaches Summarized

Simons (1971:341), in his discussion of reading comprehension, suggests six major theoretical approaches. These are: the skills, measurement, factor analytic, intercorrelational, introspective, and models approach to reading comprehension.

The skills approach primarily involves the selected use of a category of skills that appear to account for comprehension of written material. However this viewpoint has at times failed to differentiate among the three categories of activities in the discussion of comprehension skills. These are: uses of comprehension, procedure for teaching comprehension and the psychological processes involved in reading comprehension (Simons, 1971:344).

The measurement approach primarily involves the use of standardized reading comprehension tests. However, these tests lack construct validity and thus the extent to which these tests are measuring other factors related to comprehension cannot be determined (Simons, 1971:348).

The factor analytic approach primarily involves the use of psychometric and statistical techniques to measure the common factors involved in reading comprehension. However, as Simons (1971:348) suggests, the lack of solid theoretical models of comprehension results in the conclusion that reading comprehension is composed of the same skills that the approach measures.

Another approach, related to the factor analytic approach, involves the intercorrelation of test results used to measure comprehension. As in the factor analytic approach a problem results because the tests define comprehension in terms of the tests that are used to measure comprehension.

The fifth approach, cited by Simons (1971:353), involves the function of introspection. In this approach readers are asked to describe verbally how they arrive at the answer they gave in response to the comprehension questions. However in this approach the relationship between the subject's verbal description and the mental processes employed are difficult to account for. Further, the relationship between the mental processes involved in answering the comprehension questions, after reading, and the mental processes involved during the reading process can not be accounted for.

The sixth approach cited by Simons is the models approach. This approach is useful in generating testable hypotheses which can be evaluated through empirical research. Simons (1971:352) suggests that this approach will ultimately lead to a theory of reading comprehension. However severe limitations in this approach can result if the models used are too vague and global and if they are not based on an adequate theory of language.

## A Viable Theoretical Approach

Simons (1971:355) suggests that a viable theoretical approach can be found through the use of Chomskian linguistic theory and psycholinguistic research. However this viewpoint also involves a number of limitations. Initially, Chomsky affirms the existence of an innate fixed core (language acquisition device), which determines the basic structure of language (Piaget, 1973:11). Briefly, the language acquisition device is comprised of the linguistic universals and the evaluation measure. The language acquisition device takes the primary data as input and specifies the form of grammar of the possible human language (Chomsky, 1969:67). The other component, the evaluation measure, selects the grammar of the appropriate form that is compatible with the primary linguistic data. As Derwing (1973:70) suggests, it is the processing of the grammar in this innate core that results in the deep structure of the lanquage components.

Principally, the problem results because the reality of the language acquisition device is contingent upon one's view of the inner nature of man, and man's innate predisposition. This view, concerning the characteristic of innateness of man, is impossible to test primarily because of the essential interdependence or interaction, between the factors of heredity and environment (Anastasia, 1958:68).

On the other hand, these limitations could be possibly eliminated by assuming a Piagetian constructivist view of language and logical development. This view would attribute the beginning of language structures to the pre-existing sensory motor intelligence, and thus would not ~~totally recognize external~~ preformations (empiricism) nor innate preformations (innateness) (Piaget, 1973:11). Language would systematically arise through the development of intelligence. In this sense Piaget would sanction the interdependence of language and thought but would not consider language to be a sufficient condition for the constitution of the intellectual operations (Sinclair-De-Zwart, 1969: 317). In essence, Piaget views language as a ready-made system which is elaborated by society, and which contains a wealth of cognitive instruments, such as relations, at the service of thought (Sinclair-De-Zwart, 1969:326). These cognitive instruments comprise a code which is precisely the code that is used to express knowledge.

If one can assume, as Simon (1971:355) suggests, that language is a major component of reading comprehension and if one can further assume that language and thought or reasoning are interrelated, then thought must also be a major component of reading comprehension. Furthermore, since cognitive instruments in language are used to express knowledge and language is a major component of reading comprehension, then these cognitive instruments must also be used in reading comprehension to express knowledge.

Sinclair-De-Zwart (1969:318) suggests that an essential, functional prerequisite to the development of language in the child and hence to reading comprehension, is the symbolic function. The symbolic function can be principally viewed as a capacity to represent reality through the intermediary of signifiers that are distinct from what they signify (Sinclair-De-Zwart, 1969:318). However with the acquisition of language, language takes the place of symbolization in the relationship of the knower-symbolization-known. Language is, in itself, an object of the known; thus when Piaget stresses primarily the knower in the knower-known relationship, the psycholinguist stresses the known (Sinclair-De-Zwart, 1969:326).

This notion has a number of significant implications for reading comprehension. Principally a theory of the development of reading comprehension would have to be based on a theory of the developmental changes in the knower-symbolization-known relationship, essentially on genetic epistemology. However this theory would also have to be based on the formal properties of language; in other words on linguistic theory. As Sinclair-De-Zwart (1969:326) suggested, to understand how something is acquired we also have to know what is acquired.

## Interrelationship of Language and Logic and Importance to Reading Comprehension

In a study by Sinclair-De-Zwart (1969:322), an attempt was made to study precisely the interrelationship between language and logic. Specifically, she wished to see whether a child who lacks a certain concept or operation would make operatory progress after having undergone verbal training. The verbal training was aimed to make the child acquire the expressions used by children who already possess the concept in question. Even though the number of subjects was not given in the study, only ten percent of the subjects who had acquired the concrete operations tested showed an improvement in the use of concrete operations after the verbal expressions were taught. Further, the results of this study indicate that verbal training for children (who had not as yet acquired the operations of conservation) made little or no difference in the acquiring of the operations of conservation (Sinclair-De-Zwart, 1969:325).

Furth (1966:117) conducted a study involving 22 deaf children of a mean age of 8 years 5 months and 22 hearing children of mean age 6 years 10 months, to determine if there was any difference in the acquiring of the logical operations, i.e. conservation of weight. The deaf children were defined as typically deaf. This implies a significant language deficit in comparison to a hearing person (Furth, 1966:15). The results suggested that the difference in performance of the two groups was not significant to warrant support for the notion that language is a requirement for children to achieve the conceptualization of conservation of weight (Furth, 1966:120). The results of these two studies suggest further that language is not the source of logic but is rather structured by logic.

## GLOBAL VIEWPOINT OF READING COMPREHENSION IN THIS STUDY

As suggested previously the interrelationship of language and logic as outlined by Sinclair-De-Zwart and Piaget is particularly important to the development of a theoretical point of view of reading comprehension. The importance lies in the fact that comprehension in reading cannot be viewed strictly in terms of language as Simons (1971: 355) suggests, but must also take into consideration the development of logical operations.

Accepting these viewpoints, reading comprehension can generally be viewed as an active, dynamic, developmental process, in which the reader is an active participant, relying on and applying both his knowledge of language, and logical operations. Principally, reading comprehension can be viewed as a thinking process.

Thinking is in turn defined as "the mental transformations employing surrogates of events, objects and processes, or properties and relations thereof" (Neimark and Santa, 1975:173). Thinking in behavioral terms is "an instance of a complex concept having cognitive, skillful, intentional and performance properties" (Bourne, Ekstrand and Dominowski, 1971:7). As Bourne et al. (1971:6) suggest, what a person knows what he knows how to do, what he wants to do and what the person does, must be considered when dealing with thought. In this study thought is assumed to involve a conceptual and relational basis, encompassing both a cognitive and behavioral component. However, as Rawson (1965:43) and Piaget and Inhelder (1969:90) note, language is interrelated with thought and is primarily an instrument of thought.

## MORE SPECIFIC VIEWPOINT OF READING COMPREHENSION IN THIS STUDY

For the purposes of this study, this view of reading comprehension is far too global; thus reading comprehension will be viewed in terms of Hunkins' (1976:22-41) and Sanders' (1966:1-154) Taxonomy. Hunkins and Sanders' Taxonomy is based on Bloom et al. (1956:62-199) Taxonomy of Educational Objectives: Cognitive Domain and suggests that the comprehending of reading material involves a number of progressively higher and more complex levels. These are: memory (knowledge), translation, interpretation and extrapolation, application, analysis, synthesis, and evaluation. These levels of thought are in turn also dependent upon the development of logical operations and concepts. As Lovell (1968:231) suggests, systematic thinking requires that precise relations be established among concepts. Concepts cannot exist alone, and owe their precision and lack of precision to the relationship with other concepts. Essentially, concepts require a place in a conceptual system. This placement in a conceptual system requires systematic ways of relating concepts to one another and these ways are principally the classificatory system and logical operations of classification.

The writings of Jenkinson (1973, 1975, 1976), Rawson (1965, 1969), Kretschmer (1972, 1974), Elkind (1976), Kachuck and Marcus (1976), Henry (1974) and Gerard (1975) tend to lend some support to this viewpoint.

Jenkinson (1975:1) views reading comprehension primarily as an interrelationship between the author and the reader through the use of written language. Jenkinson (1973:45) notes that reading and reading comprehension is a form of thinking or reasoning, which involves analyzing and discriminating, judging, evaluating and synthesizing. Implicit in her view is that reading must include the interpretation and evaluation of meaning as well as the reconstruction of meaning. In addition, it is essential that the reader grasp both the literal meaning and the author's purpose. This can be accomplished by the reader examining how the author presents ideas in different kinds of paragraphs. In this case the paragraph could be introductory, definition, description, illustration, explanatory, transitive and summary. The reader should realize that the author is attempting to communicate ideas and thus it is essential for the reader to follow the author's thought (Jenkinson, 1975:3). Essentially, this can be accomplished by mapping out the author's thoughts. These maps can involve the diagramming of linear thinking, correlated ideas, hierarchical presentation, two and three dimensional matrices and overlapping correlates (Jenkinson, 1975:5).

The recognition and construction of these maps however requires the mature development of the operations of classification.

Rawson (1965:88) lends further support to this view by suggesting that comprehension is not always entirely concerned with word meaning, concepts and vocabulary. There are in addition basic logical operations underlying reading comprehension, and these operations, once acquired, apply and reapply to new context. She points out that the operations of classification are specifically applicable to finding the main idea in a passage or paragraph, and to indicate the relationships of the supporting ideas to the principal idea (Rawson, 1965:62). This would involve the surveying of the material as a whole, a search for possible differences and similarities and the downward search for the subordinate parts of the organization (Rawson, 1965:62). However, if the operations of classification are not sufficiently developed the reader may make a number of errors in classification. He could rely on an ascending technique and sort the details into little collections, and fail to produce an integrated organization. Furthermore, he may fail to shift his criteria to include all the data, and then block out some of the more relevant information (Rawson, 1965:62).

Kretschmer (1974:181) asserts that a major component of reading comprehension is reasoning, and that the stage of the reader's level of cognitive development may significantly affect his ability to reconstruct the meaning of what he reads. If an individual has difficulty in comprehending written material, this may be due to the incomplete development of concrete operations in general, and the concrete operations of classification and seriation specifically. In addition, the individual may have difficulty applying the concrete operations to the reading format (Kretschmer, 1972:31). This difficulty may be due to the more abstract nature of the reading task or the reader may fail to see the applicability of the operations to the reading task (Kretschmer, 1972:97). Piaget (1967:62) notes that up to the age of eleven to twelve the operations of classification are primarily concrete. Essentially, they are concerned with reality itself, and with particular objects that can be manipulated and subjected to real action.

Elkind (1976:336) views reading comprehension as an active process and notes that visual independence, meaning construction and receptive discipline are involved in successful reading comprehension. Through visual independence, the visual verbal system becomes more independent of the sensory motor system, and the reader is more able to rely on conceptual inferential processes to process the text. In meaning construction three types of learning are involved: knowledge (the construction of concepts through logic, deduction and induction), representations (the construction of words and images by imitative processes that primarily involve observation and modeling) and meanings (the coordination of knowledge and representations) (Elkind, 1976:336; Elkind, Hetzel and Coe, 1974:6). Receptive discipline is the development of the ability on the part of the reader to be simultaneously passive (being receptive to the representations of others) and active (interpreting the representations within his own framework) (Elkind, 1976:338). The development of these three aspects of reading comprehension (visual independence, meaning construction and receptive discipline) are all based on the prior development of: (1) a language rich environment, (2) attainment of concrete operations, (3) a program of instruction, and (4) a suitable adult reading model who rewards reading behavior.

Kachuck and Marcus (1976:157) assert that by approximately ages 9 to 12, children are capable of classification of relational units; can hold subordinate and superordinate concepts, are capable of reversible transformations of thought; and can cope with inversions and reciprocal relations. These abilities are directly related to the concrete operations and reading comprehension; however readers may experience difficulty applying and relying on these abilities in attempting to reconstruct the meaning of what they read. This could be a possible explanation of poor reading comprehension (Kachuck and Marcus, 1976:157). They suggest that it may be productive to teach children how to apply and rely on these mental abilities and strategies when reading.

Henry (1974:6) views reading comprehension primarily as concept development, involving two modes of thought, analysis and synthesis. He generally views analysis as the breaking of the whole into parts, and synthesis as the combining of the parts into the whole. This process of conceptualization involves four basic operations: (1) the act of joining or being together, (2) the act of excluding or discriminating and negating and rejecting, (3) the act of selecting and (4) the act of implying (Henry, 1974:15). These operations are precisely the four major logical operations of relation which Piaget considers essential in describing the development of thought. Piaget defines these as negation, conjunction, disjunction and implication (Piaget, 1952:x).

Gerard (1975:viii) points out that the grouping of ideas and experiences must be understood if efficient reading is to take place. This grouping of ideas is facilitated by the reader's use of function words. These function words are "and," "but," "in spite of," "although," "regardless," "as a result of," "because" and "either or." Again the correspondence here is very similar to Piaget's four major logical operations of relations. Gerard (1975:110) further points out that the primary organizational factor of reading comprehension is categorization or classification, and in this context, paragraphs, through the use of a topic sentence, can be transcribed into categories or classes.

The analysis of these views of reading comprehension lend support to the notion of reading comprehension as an active thinking process on the part of the reader. These views also lend support to the notion that the operations of classification may be an integral part of the process of reading comprehension.

Reading comprehension, in this study, is viewed as an active and developmental, reconstructive process involving the logical operations of thought in general and the logical operations of classification specifically. Implicitly, the reader must also rely on language, and knowledge of concepts to reconstruct the author's meaning. This reconstruction can be carried out at the following levels of cognitive activity: memory (knowledge), translation, interpretation and extrapolation, application, analysis (deduction), synthesis (induction) and evaluation. Basic to all these levels of reconstruction are the concrete operations of classification.

## RELATIONS OF CLASSIFICATION AND READING COMPREHENSION

Basic to the understanding, learning and applying of class concepts specifically and other concepts in general (in reading comprehension) is the understanding of relations. This understanding of classes and relations is essential to the development of implicative relations. Implicative relations are defined as relations between mental states, and are essentially logical relations.

e.g. If (A = B) and (B = C) then (A = C). (Rawson, 1965:92)

A number of relations involved in reading comprehension and classification are:

1. The relations of class membership. This relation may be

expressed by the words "is an" and requires putting into correspondence intensional and extensional properties of a class. (A dog is an animal.) (Rawson, 1965:94)

2. The inclusive relations between a subclass and a superordinate class in a hierarchical structure. (Birds are animals.)

3. The relation between a class and its complement combined to form a hierarchical class structure (A and A′). (Pintails and other ducks.)

4. The additive subclasses and superordinate class relations in a hierarchical class structure. (Pintails and other ducks are birds.)

$$A + A' = B$$

$$A = B - A'$$

5. The matrix class relation and the ordering of the subclasses in the matrix structure.

6. The relation of class intersection. This relation requires the understanding of conjunction and disjunction. These relations are expressed by "and" and "or" and by other stylistic variants, such as although, even though, but, in spite of the fact that, either or (Rawson, 1965:95). These logical relations are normally expressed by connectives.

If one principally views reading comprehension in terms of thinking, and if one assumes that thinking has a conceptual and relational basis, then reading comprehension must also have a conceptual and relational basis. As discussed previously, the relations of a member of a class, the relations of inclusion, the relations between a class and its complement combined to form a hierarchical class structure; the additive relation between subclasses and the superordinate class in a hierarchical class structure, the matrix class relation and the relation of class intersection are basic to the understanding, learning and applying of class concepts specifically and other concepts in general. If one accepts the assumption that reading comprehension has a conceptual and relational basis, then the above mentioned relations must be involved in reading comprehension.

The relations of a member of a class is involved in reading comprehension primarily in terms of identifying the attributes of the specific concepts and classes presented in written discourse and in identifying the members or elements that may belong to the class or concept.

e.g. A bird is an animal.

Bob is a happy man.

The relations of inclusion between a subclass and a superordinate class; the relations between a class and its complement combined to form a hierarchical class structure, and the additive relation between subclasses and superordinate class in a hierarchical class structure may be involved in reading comprehension in the following manner:

1. The relating of first order concepts based on the manifest properties of objects (size, color, shape) to second level concepts or collectivities based on similarities and differences (common and essential features) and the final relating of the first and second order concepts to third order concepts based on the abstraction and

relation of essential features. This final abstraction and relation of essential features permits the extension of these in a hierarchically ordered system.

For instance,objects and words such as train, car, bus, plane, wagon, bicycle and sailboat may be perceived, named and read. These objects may also be associated graphically with visits, friends, family, and games. They may be further collected into fast and slow, big and little, and for long distance and short distance. However the meaning of these concepts or objects is not fully understood until the essential characteristics have been abstracted and through a set of relations placed in an ordered hierarchical system.

e.g. Man's System of Transport (Rawson, 1965:61; Smith, 1975:18).

2. Rawson suggests that essential to the development of these relations and higher order concept or classes is the simultaneous development of a heuristic approach or mental set. This mental set is primarily described as a "what have we here" kind of attitude. This mental set is essential in reading comprehension to the establishment of the universe of discourse, the frame of reference or the context of what is read (Rawson, 1965:61).

3. The relations of hierarchical classification may also be related to the finding of the main idea of a paragraph and to indicate the relationships of the supporting ideas to the principal or superordinate idea (Rawson, 1965:62; Gerard, 1975:110; Kachuck and Marcus, 1976:160; Jenkinson, 1975:3).

Rawson (1965:62) suggests that this could involve the surveying of the material as a whole; a search for the possible similarities and differences; and the downward search for the subordinate components of the organization. However, if these hierarchical relations or operations are not sufficiently developed, the reader may rely on an ascending technique and sort the subordinate ideas or details into little collections and fail to produce an integrated whole. Furthermore he may fail to shift his criteria to include all the data and thus block out some of the more relevant information. This ability to shift criteria appears to be related to the development of flexibility and the strategy of anticipation.

4. The operationalization of the relations of hierarchical classification and third order concept formation may also lead to more efficient recall.

Lange and Jackson (1974:1065), in a study involving 12 first, fourth, seventh and tenth grade students and 12 college students, attempted to assess the extent to which characteristics of children's personal categorizing schemes were related to age and the number of items recalled. They found that older subjects demonstrated an increasing preference for class inclusion organizational strategies to aid recall. The number of items recalled per cluster also appeared to increase with age. Lange and Jackson's (1974) findings appear to lend support to Piaget and Inhelder's (1973:380) view that the storage and retrieval of information is directly determined by the child's organizational operations.

The matrix class relation and the ordering of the subclasses in the matrix structure may be applicable to detecting the organization of an article, and contribute to the continuity of meaning within the article (Rawson, 1965:85; Jenkinson, 1975:4).

In presenting an article in a matrix structure the writer may use a number of cues. First, he may introduce the passage by placing a key multiplicative class in a prominent position.

e.g. The vegetation on the south slopes of the higher peaks . . .

Second, through use of suggestions the author provides the reader with clues as to how to organize the ideas. He may also alert the readers to the related classes to be constructed. The second and third paragraph may begin with the following:

At the intermediate levels one finds . . .

At the foothills is found another . . . (Rawson, 1965:86).

At this point the writer has provided the reader with enough information so the reader can construct one division of the matrix (either $B_1$ or $B_2$). Third, through the use of specific function words, punctuation and placement of key phrases, the writer may reorient the reader.

e.g. Northern exposures, however show a different pattern . . . (Rawson, 1965:86).

| | | Elevation $B_2$ | | |
|---|---|---|---|---|
| | | Higher levels $A_2$ | Intermediate $A'_2$ | Foothills $A''_2$ |
| Exposure $B_1$ | South $A_1$ | | | |
| | North $A'_1$ | | | |

Figure 13

Matrix for Rawson Example: Matrix Classification

In essence, the writer provides some direction in his logical organization of the text, and provides some direction for the reader's thinking; however the reader has to provide the essential logical operations to systematically organize and comprehend the information (Rawson, 1965:87).

5. As in forming hierarchical class structures, the reader may also have to rely on certain heuristic structures. He may have to be further able to rely on hindsight and foresight (looking forward and looking back) with focus, and thus be flexible in the multiplicative classes he forms. Initially the reader may classify the elements or ideas presented into a multiplicative classification. However, to reorganize or reclassify the elements into another class or arrangement, may require the further use of foresight and hindsight. The reader may have to hold the former class, and refocus to construct another class in the matrix. In the final organization and placement of the multiplicative classes in the matrix the reader may also have to be flexible.

The relations of class intersection and the correct usage of the quantifiers all and some are basic to the child's understanding of the concepts of conjunction and disjunction (Rawson, 1965:100). Principally, the child has to be able to recognize the three subclasses and understand the interrelations of these classes in the basic intersection model. The overlapping classes may be related in terms of conjunction or disjunction.

The difficulty with the relations of intersection involving conjunction can be evidenced by young children having difficulty comprehending the following situation and question:

Situation: All the children who brought a bicycle and their lunch to school could go on the picnic.

Question: Ann brought her bicycle to school but she couldn't go on the picnic. Why?

This difficulty may be due to the logical operations and relations of intersection not being fully operational and thus the child may overlook the significance of the logical connective "and" (Rawson, 1965: 102).

The overlapping classes in the intersection model can also be expressed by the connective "or." This is indicated in the following situation and question:

Situation: All the children who brought their lunch or lunch money or both could go on the picnic.

Question: Ann brought lunch money. Could she go on the picnic? Why?

Again, the child who has not fully developed the operations of simple multiplication or intersection, may experience difficulty in fully understanding the disjunctive relations of the classes expressed by the connective "or."

The overlapping classes and class relations expressed by conjunction ("and") and disjunction ("or") may become more difficult to comprehend if the classes consist of statements (propositions). One of the factors contributing to this difficulty is the use of negation in the selection of the subclasses.

e.g. There had been a hot sun with no rain (for months).

$(p \cdot \overline{q})$

He had no training but he was willing (to learn).

$(\overline{p} \cdot q)$

He had no training and he was not willing (to learn).

$(\overline{p} \cdot \overline{q})$ (Rawson, 1965:107)

The following sentence represents the conjunction:

Given time and a lot of care he will recover.

$(p \cdot q)$

Piaget and Inhelder (1964:150) note that the operations of negation are not fully developed and understood before the level of formal reasoning. This may partially account for the added difficulty young children may experience in dealing with propositions and connectives "and" and "or." Even if the child understands the connectives "and" and "or," he may still experience difficulty if he is not made aware of the stylistic variants of these connectives. A number of these are: although, but, even though, in spite of the fact, and yet (Rawson, 1965:107).

The notion that these concepts are developmental and relate to classification is supported by the following studies.

Neimark and Slotnick (1970:452) attempted to assess children's and college students' understanding of the relations of class inclusion and exclusion, class intersection (A and B) and class union (A or B). The sample consisted of 455 grades three to nine students and 58 college students. In general, they found that the number of correct answers increased with age. Neimark and Slotnick (1970:453) also found that the mean performance of the groups differed significantly between age groups in class inclusion and exclusion, intersection (and) and disjunction (or). In all the tasks the college students were superior, and if the college students were removed the seventh, eighth and ninth grade students performed better than all the other students (Neimark and Slotnick, 1970:455).

Suppes and Feldman (1971:307) attempted to assess the extent to which children between the age of 4 and 6 could comprehend logical connectives. "Conjunctive," "disjunctive," "negation" and "exclusive or" logical connectives were presented orally to 64 subjects. The subjects responded correctly to 71 percent of the conjunctive relations, 67 percent of the exclusive relations, and 11 percent of the disjunctive relations. Significant differences were found between conjunctive and disjunctive relations and between exclusive or and disjunction relations ($p < .001$). Negation appeared to significantly increase the difficulty of all tasks ($p < .01$) (Suppes and Feldman, 1971:307).

In another study, Paris (1973:279) assessed the extent to which grades two, four, eight and eleven students understood verbalized propositional relationships. The 40 students in each grade were presented with conjunctive, conjunctive absence (neither-nor), disjunctive inclusion or exclusion (or, either or), conditional (if then) and biconditional (if and only if then) logical relations. Paris (1973:287) found that all groups had little difficulty with the conjunctive relationships. The subjects' performance with disjunctive, conditional, and biconditional connectives improved with age. In general, subjects found conjunctive relationships easiest to understand with biconditional and conditional relationships following in that order.

Youniss and Furth (1964:357), primarily relying on a visual learning experimental condition, presented grade four, five, six and seven students with three types of connective concepts. The three concepts were the conjunction of A and B (and), the exclusive disjunction of either A or B, but not both (or), and the joint absence of A and B (not). In general, Youniss and Furth (1964:359) found a trend indicating more errors in successively lower grades. For the grade four subjects, no differences were found in the concepts learned; however the grade five, six and seven students appeared to find the conjunctive concepts "and" significantly easier than either the exclusive disjunction "or," or the conjunction absence "not."

The previous studies cited all appear to indicate that:

1. The development of children's concepts of connectives and logical relations may be age specific, and appear to improve with age.

2. The concept or logical relation of conjunction appears to develop prior to the development of disjunction.

## THE NATURE OF CONCEPTS

The reader's knowledge of concepts is considered to be a basic component of the thought processes involved in reading comprehension. Concepts can assume four major forms: class concepts, dimensional concepts, explanatory concepts or principles and singular concepts. Johnson (1972:33) views class concepts as discrete structures which can be defined to designate a set of elements satisfying some criterion or else the criterion itself. The set of elements of the class concept provides the extensional definition and the intensional definition is satisfied by the criterion. Class concepts are either unidimensional (characterized by one attribute) or multidimensional (characterized by two or more attributes). Multidimensional class concepts are comprised of conjunctive, disjunctive, and relational class concepts. Conjunctive class concepts are comprised of the conjunction of two or more attributes and dimensions, and disjunctive class concepts may be defined by either of two or more attributes. However, relational class concepts may be primarily defined by the relationship between attributes rather than only by the presence of attributes.

e.g. The class of couples in which the wife is taller than the husband. (Johnson, 1972:35)

In regards to these concepts, attributes are defined as continuous as well as discrete (Johnson, 1972:35).

Dimensional concepts essentially consist of locating objects or elements on abstract dimensions. Johnson (1972) defines dimensions as "continuous properties, qualities or attributes abstracted and generalized from specific objects and events" (p. 35).

e.g. The use of "great big," "very small" and "tiny" on a continuous basis.

Explanatory concepts can be viewed as an explanation or principle. The primary function of explanatory concepts are to state a relationship between concepts, dimensions or class concepts. The principle usually takes the form of a proposition and thus may be true or false (Johnson, 1972:36).

Singular concepts refer to one's private conception of a single object or event. The conception may be a single term referring to one's cluster of memories, experiences, perceptions, affects and associations, and is based on direct experience (Johnson, 1972:36).

Piaget and Johnson's view of concepts and classes tends to rely on "Abstraction Theory" and uses the notion of class as a means to categorize concepts. Markman and Seibert (1976:526) find that this view results in a number of problems:

1. Natural concepts and classes may not be capable of being described by clear cut, and necessary and sufficient conditions.

2. Abstraction theory assumes that instances either meet the criteria of the class or not, however some instances are clearly better than others.

3. The traditional view of concepts fails to consider concepts which cannot adequately be characterized as organized into class inclusion hierarchies. This primarily refers to collections which are the referents of collective nouns, e.g. family, pile. In dealing with these collections the elements of extension must be considered in conjunction with the criteria. Markman and Seibert (1976:563) further suggest that concepts should also be viewed in terms of collections and objects.

Collections differ from classes in at least three ways. First, the manner in which membership is determined. In terms of class membership, an object or element is measured against the defining criteria of the class; however, in terms of membership in a collection, one is concerned with the relationship of the object or element to the other members. For instance, if one wishes to determine if a block is an element of a pile of blocks, the spatial relationship of the block to the other blocks must be considered.

Second, part-whole relationships. In essence, a class is part of a higher order class and is included in the class. A collection can also be a member or part of a higher order class or collection; however, collections are not instances of the elements that define the higher order class. For instance, children are members of a family or part of a family, however they are not instances of types of families (Markman and Seibert, 1976:563).

Third, the internal organization and the nature of the whole formed. In essence, classes have no internal organization and result in a whole only in an abstract sense; however, collections have some degree of internal organization and result in an organized whole.

e.g. a flock of birds

Objects primarily differ from classes in that the elements of an object are highly organized. For example, the class of all parts does not make a machine, primarily because the component parts must be organized in a particular way (Markman and Seibert, 1976:564).

High Relationship → Little Relationship

Object Concept → Collective Concept → Class Concept

Figure 14

Degree of Organization for Object, Collection and Class

## RESEARCH SUPPORTING THE PIAGETIAN VIEW OF CLASSIFICATION AND READING COMPREHENSION

One of the few individuals that has seriously researched the relationship between reading comprehension and the Piagetian view of cognitive development is Rawson. Rawson (1969:5) attempted to assess the extent to which readers age 9 to 10 years of age can apply and rely on the logical operations of classification, conservation, deduction, induction, and probability reasoning in both a concrete task and a reading situation. The total sample consisted of 50 boys and girls selected on a random basis from regular grade four classes. In general, Rawson (1969:218) found that the scores on the concrete tasks were higher than the scores on the stories tasks. Rawson (1969:287) found a highly significant correlation ($p < .01$) between the concrete and reading situation tasks in the following areas: concrete deduction and reading conservation, concrete conservation and reading classification, concrete classification and reading probability, and concrete induction and story deduction. However, the product moment correlation for reading and concrete classification was only .13 (Rawson, 1969:241). This suggests that the operations of classification available to grade four students may not be equally available in both a reading and concrete situation. Essentially, these readers may have difficulty applying these operations in the reading situation. These findings appear to be consistent with the Piagetian view of the development of the operation of classification and concrete operations. Piaget and Inhelder (1964:149) point out that the operations of classification of stage three are not transferable from a concrete to a unique situation until the initial stages of formal operations. The beginning of this transfer could be expected between the ages of ten and eleven.

Kretschmer (1972:22-25) attempted to construct an experimental instrument based on Piaget's conceptualization of the eight logical operations of concrete operation, to measure thinking within the context of reading. He devised four major paragraphs, additive classification, multiplicative classification, additive seriation, and multiplicative seriation, and administered these paragraphs and corresponding questions to 60 third grade and 60 sixth grade subjects. The test instrument, devised by Kretschmer, consisted of a series of reading passages and related comprehension questions. These comprehension questions were in a multiple choice format and were designed to measure the extent to which the subjects were able to rely on the operations of classification in comprehending what they read. No explanation was required on the part of the subjects to justify their responses, thus no analysis of the nature of the rationale was possible. In addition, Kretschmer (1972:22-24) primarily dealt with the major groupings of additive and multiplicative classification and seriation; hence the more specific operations or dimensions of classification that were required to complete the comprehension task, were not identified.

The Pearson product-moment correlation for the third grade subjects, between additive classification and the Iowa Silent Reading Test was .51. The correlation between the same reading comprehension test and multiplicative classification was .40. For the sixth graders, the correlation between additive classification and performance on the

Monroe Sherman Reading Comprehension Test was .49, and performance in multiplicative classification and the standardized reading comprehension test was .50 (Kretschmer, 1972:52). All these correlations were significant at the .05 level of significance. These correlations, although significant, would have very little predictive value. In addition, these correlations would suggest that the experimental tests may be measuring an aspect of reading that is not measured on standardized reading tests. This could be the operations of classification applied to reading.

In general, the third-grade readers performed at the 45 percent success level and the sixth graders performed at about the 65 percent level. This suggests that third and sixth grade children do apply the cognitive operations of classification to the reading context; however the sixth grade subjects tended to be more proficient.

What may account for this difference was not discussed by Kretschmer. It appears conceivable that the third grade subjects may not have fully developed these operations; even with the use of concrete props and familiar situations. On the other hand, the third grade readers may have difficulty applying these operations to a reading situation.. This could be due to the more abstract nature of reading tasks. Jenkinson (1976:61-64) suggests that this is attributed to the following factors: (1) meaning must be reconstructed by directly analyzing the written language, (2) reading material is more ideational, (3) the written language is comprised of more deeply embedded items and a greater density of concepts and (4) the ideas presented tend to be more organized and contained in larger units of thought. Walker (1976:147, 1973:52) supports this notion by noting that the processing of written language, as opposed to the processing of oral language, requires greater precision; principally because the general ideas in printed language are presented in a more logical structured way.

This difficulty in relying on the logical operations of classification in the reading context may also be due to the child not having ready access to the concrete props. Piaget (1967:62) notes that up to the age of 11-12 the operations of intelligence are solely concrete. In essence, these operations are concerned with tangible objects that can be manipulated and are subject to real action. The operations of intelligence before the age of 11-12 years are also highly susceptible to the context and contents of the situation (Piaget and Inhelder, 1964:110).

These studies by Rawson (1969) and Kretschmer (1974), and the viewpoints of Jenkinson (1973, 1975, 1976), Elkind (1976), Henry (1974), Gerard (1975) and Kachuck and Marcus (1976) lend support to the notion that the operations of classification are an implicit component of reading comprehension. Furthermore, it seems conceivable to the researcher, that readers must have access to these operations of classification in a concrete situation before they can consistently rely on and apply these operations to a reading context. It also seems probable that some readers may have access to these operations when they can rely on concrete props but fail to apply these operations when attempting to comprehend what they read. This may partially account for the difficulty that less proficient readers experience in reconstructing the meaning of what they read. On the other hand, it also seems plausible that more proficient readers or high comprehenders may be more able to rely on and apply the operations of classification in a reading context and thus may be more proficient in reconstructing the meaning of reading material specifically involving the use of these operations.

This essentially, is the purpose of this study; to assess the extent to which more proficient and less proficient readers are able to perform the operations of classification in a concrete situation and in a reading situation.

In contrast to Rawson's (1969) study, this study will utilize a population of grade six students ages 11 years 1 month to 12 years 4 months. Furthermore, rather than relying on a general population of readers as in the case of Kretschmer's (1972) and Rawson's (1969) study, this study will utilize two groups of readers, a high comprehending group (more proficient readers) and a low comprehending group (less proficient readers). In addition an attempt will be made to more qualitatively assess and analyze the test responses of the two groups of readers in terms of five major dimensions or operations of classification:

1. Abstracting critical properties which define membership in a class (Construction of Classes)

2. Inferring class inclusion relations (Class Inclusion)

3. Constructing predicates which describe the extension of dichotomous classes (Predicates)

4. Constructing and ordering multiplicative classes (Matrix

Structure)

5. Constructing simple multiplication classes (Intersection).

## SUMMARY

In this study, reading comprehension is viewed as an active, dynamic, developmental, thinking process, in which the reader is relying on and applying his knowledge of language and logical operations to reconstruct the meaning of the text. The operations of classification and relations are considered to be an essential and basic component of thought and of reading comprehension. The theoretical viewpoints and research discussed in this chapter suggest that less proficient readers may have more difficulty than more proficient readers in relying on and applying the operations of classification to the reading context.

# CHAPTER IV

# EXPERIMENTAL DESIGN

The design of the study will be discussed in this chapter. The chapter will also include a description of the student population and the sample, the test instruments, the treatment procedures, and the statistical treatment of the data.

## THE DESIGN OF THE STUDY

The purpose of this study was to investigate the extent to which more proficient and less proficient readers could perform the logical operations of classification in both a concrete and reading situation. To achieve this purpose the study was conducted in three stages. The first stage involved the further development of Rawson's (1969:326-335) research instrument required to measure the logical operations of classification in a reading and concrete situation. The second stage consisted of a pilot study to assess the extent to which the test instrument was useful in assessing the logical operations of classification in a reading and concrete situation. This second stage also involved the reappraisal of the updated Rawson research instrument and the implementation of the revisions. The third and final stage involved the collection and analysis of the data. In this phase of the study all student responses were transcribed from audiotape, and analyzed both qualitatively and quantitatively.

The design principally can be described as consisting of two, two factor experiments (factor A and B) with two repeated measures on factor B (Winer, 1962:302). Factor A (groups) for both experiments consisted of two groups, more proficient readers and less proficient readers. Factor B in one case consisted of additive classification, reading and concrete and in the other case multiplicative classification, reading and concrete. In this study all the subjects in the two groups were observed under all the conditions.

## THE STUDENT POPULATION AND SAMPLE

The population from which the research sample was chosen involved seven classes of sixth-grade students from three city schools. The schools were assigned the researcher by central office personnel from the school system in which the study was carried out. The total number consisted of 219 students. From this population of 219 students, 50 subjects, 25 less proficient and 25 more proficient readers, were selected. The selection criteria and procedure are discussed in the next section. The sample consisted of 23 girls and 27 boys. From each group of subjects, less proficient and more proficient readers, 5 subjects were chosen and assigned to the pilot study. The remaining sample of 40 students, 20 more proficient and 20 less proficient readers, were assigned to the main part of the study. Of these 40 students, 22 were boys and 18 were girls. The ages of the less proficient readers ranged from 11 years 1 month to 12 years 4 months, and the ages of the more proficient readers ranged from 11 years 1 month to 12 years 3 months. The mean ages of the two groups respectively were 11 years 8 months and 11 years 7 months.

Selection of the Sample

The fifty subjects were selected on the basis of their performance on the New Developmental Reading Tests: Intermediate Level, Form A and B, Bond, Balow and Hoyt, 1968. This reading test was administered to 159 students in the sample by the students' classroom teachers in October 1976. Of these 121 received form A and 48 received form B. Form A of this test was administered by the researcher to an additional 60 students during the month of January 1977. These additional subjects were assessed principally because it was felt by the researcher that a population of 159 students was insufficient in number.

Three different criteria were devised by the researcher in an attempt to select and clearly identify these two groups of readers. Initially the selection of the 25 more proficient and 25 less proficient readers, from the total sample of 219 subjects, was based on the following four-part criterion:

1. No significant difference in the mean raw score performance of the two groups in vocabulary, Literal Comprehension and verbal and nonverbal IQ ($p \leqslant .05$).

2. A significant difference in the mean raw score performance of the two groups in Creative Comprehension ($p \leqslant .05$).

3. The less proficient readers' score in Creative Comprehension was ten or more raw score points below their score in Literal Comprehension.

4. The more proficient readers' score in Creative Comprehension five or more points above their score in Literal Comprehension.

It became apparent that as the two groups differed in their level of comprehension an equally strong difference was manifest in vocabulary and verbal and nonverbal IQ between the two groups. A second selection attempt was made based on the following four-part criterion:

1. The vocabulary scores and Literal Comprehension scores of the two groups were above the 50th percentile rank.

2. The Creative Comprehension score of the less proficient readers according to test norms was 17 percentile points below their performance on the Literal Comprehension Test (2.3 standard errors).

3. The Creative Comprehension score of the more proficient readers was zero percentile points or more above their Literal Comprehension score.

4. The verbal and nonverbal IQ score of the two groups was average or above average.

Based on this criterion 25 more and 25 less proficient readers were selected. In addition, five members from each of these groups were randomly selected and assigned to the pilot study (Fisher and Yates, 1953:116).

However, the final analysis of the two groups revealed that the groups did not differ significantly in Creative Comprehension even though there were individual score differences. This was attributed to: one, the wide range of scores for both the more proficient and the less proficient readers. The score for the less proficient readers in Creative Comprehension ranged from the 86th percentile rank to the 4th percentile rank and the scores for the more proficient readers ranged from the 96th percentile rank to the 55th percentile rank.

Second, the criterion appeared to favor individual score differences as opposed to group score differences. For instance, a subject achieving a score at the 82nd percentile rank in Literal Comprehension and a score at the 65th percentile rank in Creative Comprehension would be considered a less proficient reader. Another subject could achieve a score at the 65th percentile rank in Literal and Creative Comprehension and would be considered a more proficient reader. Essentially the two subjects do not differ in their Creative Comprehension performance.

The third and final selection attempt was based on the following two-part criterion. The more proficient readers were required to:

1. Obtain a total raw score of 38 or more on the Creative Comprehension subtests of the screening test. According to the test norms, published by Bond, Balow and Hoyt (1968:25), these subjects were at or above the 86th percentile rank.

2. Obtain a Literal Comprehension subtest score and vocabulary subtest score above the 50th percentile rank. Percentile rank based on test norms.

A total number of 22 readers from the population met this criterion. One reader was excluded because he had transferred to a school outside the city of Edmonton, and another subject was omitted because he had been included in the pilot study.

The less proficient readers were required to:

1. Obtain a total score of 25 or less on the Creative Comprehension subtests of the screening test. According to the test norms these subjects were at or below the 57th percentile rank.

2. Obtain a Literal Comprehension subtest score and vocabulary subtest score above the 50th percentile rank. Percentile rank based on test norms.

3. According to test norms obtain a Creative Comprehension percentile rank score below the Literal Comprehension percentile rank score.

A total number of 25 readers from the population met this criterion. Four readers were omitted because they had been included in the pilot study, and one subject was randomly selected and omitted from the study.

The general results of these two groups, 20 more proficient and 20 less proficient readers, on the screening test suggest that all the subjects were performing near or above the average sixth grade level, and that the comprehension difficulties which the less proficient readers were experiencing were not due to their difficulty in identifying words in context and isolation. Implicitly however three assumptions were made:

1. That a general vocabulary reading test is a rough measure of a reader's ability to identify words in isolation.

2. That a general literal comprehension test is a rough measure of a reader's ability to identify words in context.

3. That the percentile ranks provided by the authors of the screening test are roughly equivalent to grade level performance of the subjects in the population and sample.

In an attempt to control for language and intelligence, all subjects selected for the main study were of average or above average intelligence, spoke English as a first language and did not manifest any language difficulties to the researcher and teacher. Information related to intelligence was obtained from the students' performance on the Canadian Lorge-Thorndike Intelligence Tests, Nonverbal and Verbal Batteries, Form D, administered by the schools in January 1977 and entered on the students' school records. All the students who scored 92 or above on both the verbal and nonverbal subtests were included in the sample. Scores ranging from 92 to 108 are considered by the test authors and norms to be average, while a score above 108 is considered to be above average (Lorge, Thorndike and Hagen, 1967: 27). The mean scores of both groups on the verbal and nonverbal subtests were 118.65 and 120.15 for the more proficient readers and 100.65 and 108.85 for the less proficient readers. The verbal IQ scores of the less proficient readers ranged from 147 to 92, and the nonverbal IQ scores ranged from 125 to 92. For the more proficient readers the verbal IQ scores ranged from 147 to 95 and the nonverbal scores ranged from 134 to 92. Twenty percent of the verbal IQ scores and 50 percent of the nonverbal IQ scores, for the less proficient readers, were in the above average range. For the more proficient readers 75 percent of the verbal and nonverbal IQ scores were in the above average range.

### Table 7

Mean Performance and T Scores of the More and Less Proficient Readers on the Screening Tests

|  | New Developmental Reading Test |  |  |  |  |  | Lorge-Thorndike Scores |  |
|---|---|---|---|---|---|---|---|---|
| Readers | Vocabulary | % Rank | Literal Comprehension | % Rank | Creative Comprehension | % Rank | Verbal | Nonverbal |
| More Proficient Readers n = 20 | 43.55 | 84 | 43.30 | 94 | 44.00 | 94 | 118.65 | 120.15 |
| Less Proficient Readers n = 20 | 31.10 | 57 | 29.15 | 64 | 18.50 | 41 | 100.65 | 108.85 |
| Welch t | 5.83* |  | 10.01* |  | 17.46* |  | 3.99* | 2.53* |

Level of significance: *p ⩽ .02.

Information regarding subjects' language facility was obtained from student school records, and classroom teacher interview. All students who scored average or above average on the verbal subtest of the Canadian Lorge-Thorndike Intelligence Tests and who were considered by their principal teacher as demonstrating adequate competence in both expressive and receptive language abilities were included in the study. The data, to ensure that all 40 subjects in the study spoke English as a first language, were obtained from the student's classroom teacher and school records.

In examining the screening test summary as given in Table 7, the two groups are considered to be significantly different on five major dimensions: vocabulary, Literal Comprehension, Creative Comprehension, verbal intelligence and nonverbal intelligence ($p \leqslant .02$). Of interest here is that even though an attempt was made by the researcher to control for vocabulary, Literal Comprehension, and verbal and nonverbal intelligence, the two groups continued to differ significantly on all these factors. This may suggest that these factors are interrelated.

The assessment of the correlations in Table 8, of the more and less proficient readers, provides further evidence that the two groups as a whole are quite different. Principally all the correlations between the screening tests and the Creative Comprehension scores for the more proficient readers are all positive. One correlation, verbal IQ and Creative Comprehension, was significant and another correlation, Creative Comprehension and vocabulary, approached significance. However all the correlations between the screening tests and

Table 8

Correlations of Scores for More and Less Proficient Readers on the Screening Tests

| | More Proficient Readers n = 20 | Less Proficient Readers n = 20 |
|---|---|---|
| Nonverbal IQ, Verbal IQ | .63* | .52* |
| Nonverbal IQ, Vocabulary | .28 | -.02 |
| Nonverbal IQ, Literal Comprehension | .56* | .41 |
| Nonverbal IQ, Creative Comprehension | .17 | -.31 |
| Verbal IQ, Vocabulary | .27 | .20 |
| Verbal IQ, Literal Comprehension | .38 | .42 |
| Verbal IQ, Creative Comprehension | .51* | -.25 |
| Vocabulary, Literal Comprehension | .38 | -.09 |
| Vocabulary, Creative Comprehension | .38 | -.47* |
| Literal Comprehension, Creative Comprehension | .13 | -.41 |

*Level of significance: $p \leqslant .05 \leqslant .444$

the Creative Comprehension scores for the less proficient readers were negative. One correlation, Creative Comprehension and vocabulary, was significant and two correlations, Creative Comprehension and nonverbal IQ and Creative Comprehension and Literal Comprehension, approached significance. This may suggest that the less proficient readers may have more difficulty than more proficient readers in applying and relying on their knowledge and logical operations, tapped by these screening tests. This appears to be the case when functioning in a reading situation which involves the use of higher levels of thought and reading comprehension. These correlations, because of their general low level of significance and the limitation of small sample size, unequal distribution, and restriction of range, should be interpreted with caution (see Chapter VI, pp. 206-207).

The results reported in Table 7 and Table 8 for these readers are somewhat consistent with the relationship discussed by Farr. Farr (1969:179) suggests that intelligence correlates highly with performance on standardized reading tests. Kretschmer (1972:50) reported a correlation of .74 between reading comprehension and Lorge Thorndike IQ for grade six readers.

This correlation between reading and intelligence tests can be influenced by the following:

1. Verbal intelligence is more highly correlated with reading achievement than nonverbal intelligence.

2. As chronological age increases the correlations between intelligence and reading increases.

3. Reading performance itself can have a significant effect

on intelligence test performance, primarily if the intelligence test is a group test in which the test items have to be read (Farr, 1969:180).

This degree of association is not evident in the correlations presented in Table 8; however, the fact that the groups tended to differ significantly on all these factors suggests that the strength of the relationship may be stronger than is reflected by the correlations. Furthermore, these correlations may be affected by the range restriction, distribution of the variables and small sample size.

## THE TEST INSTRUMENTS

Four types of tests were administered to the subjects in this study: a standardized test of reading comprehension, New Developmental Reading Test: Intermediate Level (1968) Bond, Balow, Hoyt, stories tests of the logical operations of classification (SCO), concrete tests of the logical operations of classification (CCO) and the Digit Span Subtest of the Wechsler Intelligence Scale for Children, 1974, Revised Edition.

### The New Developmental Reading Test: Intermediate Level

This test was used to assess the subject's facility in reading comprehension. This instrument, intended for use with students in grades four, five and six, is comprised of five major segments: Reading Vocabulary, Reading for Information, Reading for Relationships, Reading for Interpretation and Reading for Appreciation. Scores from

Parts II and III, Reading for Information and Reading for Relationships, can be combined to provide a Literal Comprehension score, and parts IV and V, Reading for Interpretation and Reading for Appreciation, can be combined to yield a Creative Comprehension score. Part I, Basic Reading Vocabulary, samples the ability of the subject to recognize and associate meaning to words of increasing difficulty.

Part II, Reading for Information, is a measure of a child's ability to recall information specifically stated in the passages.

Part III, Reading for Relationships, is a measure of the ability of the subject to comprehend and recall the organization, grouping and association of ideas explicitly stated by the author.

Part IV, Reading for Interpretation. This subtest measures the ability of the subject to interpolate, and to extrapolate from the information given. In this subtest the reader is required to infer, conclude, predict, and judge critically.

Part V, Reading for Appreciation. This subtest measures the ability of the subject to appreciate the passages read. This involves sensitivity to the motivation of characters and an awareness of sensory impressions (Bond, Balow, Hoyt, 1968:2).

For all subtest items the subject was required to answer a series of multiple choice questions. Specifically with reference to Part I, Basic Reading Vocabulary, the subject was required to read a word presented to him, and then select and underline one word, from a group of four, whose meaning most closely approximated the stimulus word. This procedure was repeated for 60 items. For the remainder of the test, Parts II, III, IV and V, the subject was required to read a number of short passages and answer a series of multiple choice questions concerning each passage. Each section was comprised of ten passages and three questions per passage. For subtests II and III each test item consisted of a question and four distractors. The subject was required to select and underline the word or phrase which best answered the question correctly. For subtests IV and V each test item also consisted of a statement and four distractors. The subject was required to select and underline the word or phrase which best completed the statement correctly.

The total testing time for each section was ten minutes, and the total recommended testing time was one hour. The raw score for each subtest was obtained by subtracting the number correct from one-third the number wrong. Items not completed were not considered as errors. The Literal Comprehension score was obtained by summing the raw scores of Parts II and III, while the Creative Comprehension score was obtained by summing the raw scores of Parts IV and V. A total measure of reading comprehension could also be obtained by summing the raw scores of Parts II, III, IV and V. This was not utilized in this study. For the raw scores of all the subtests and Literal Comprehension, Creative Comprehension and Total Comprehension scores, a percentile rank and stanine rating per grade level could also be obtained from the norms tables provided by the authors. In this study the subject's vocabulary, Literal Comprehension and Creative Comprehension raw scores were used. In addition, the percentile rank norms per grade level were also utilized.

The test was standardized on a population of 15,000 American students, however the number of students per grade was not given by the authors. In establishing test reliability, 200 students from each grade were selected and administered both forms, A and B, of the reading test. Assessment of the results would suggest that the tests and test items are reasonably reliable (see Table 9).

The authors note that the comprehension test is a reasonable and valid measure of reading comprehension skills required by grade four, five and six students. Content validity was assessed by comparing the reading acts involved in each subtest with Bloom's et al. Taxonomy of Educational Objectives (Cognitive Domain). A point-biserial correlation coefficient was determined to assess the extent to which the test part-scores were correlated with the subtests. The authors claim that the correlations suggest that there is a reasonable association between the criterion measure of reading comprehension and the reading acts measured by the subtests (Bond, Balow and Hoyt, 1968:19).

With regard to construct validity, grade equivalent norms indicate that the students at each successive grade level achieve successively higher scores on each of the subtests. This would indicate that the pupils are developing these comprehension skills.

Traxler (1972), in a review of the New Developmental Reading Test, suggests that the test is an adequate measure of reading comprehension for grade four, five and six students; however a number of the items may be too difficult for students at the specified grade

Table 9

Reliability Coefficients and Standard Error of Measurement
Grade 6.5 Bond, Balow and Hoyt

| | $r_{12}$ | ra | $SE_m$ |
|---|---|---|---|
| Reading Vocabulary | .87 | .91 | 2.9 |
| Reading for Information | .85 | .89 | 2.1 |
| Reading for Relationship | .79 | .83 | 2.1 |
| Reading for Interpretation | .77 | .80 | 2.3 |
| Reading for Appreciation | .85 | .90 | 2.0 |
| Literal Comprehension | .86 | .92 | 2.9 |
| Creative Comprehension | .87 | .90 | 3.5 |
| General Comprehension | .91 | .94 | 4.9 |

(Bond, Balow and Hoyt, 1969:18)

levels (Buros, 1972:698).

The New Developmental Reading Test was selected by the researcher primarily because this was an acceptable, available test at the upper elementary school level that could be used to assess the subjects' performance in the two major domains of reading comprehension.

Furthermore, the school system in which the study was conducted strongly suggested that this test be used as a screening instrument principally because this test had already been administered in a number of schools. This would eliminate approximately 220 hours of total additional testing time.

### The Canadian Lorge-Thorndike Intelligence Test

This test, used as a rough measure of intelligence, is comprised of both a verbal and a nonverbal battery, and is applicable for students in grades three to nine. The verbal battery is comprised of five subtests including Vocabulary, Verbal Classification, Sentence Completion, Arithmetic Reasoning and Verbal Analogy. The Nonverbal Battery is comprised of Pictorial and Numerical items only, and encompasses three subtests, Picture Classification, Pictorial Analogy and Numerical Relationships (Thorndike and Hagen, 1972:4). This test is considered a group intelligence test and the students were required to read the verbal items. Essentially three quotients, verbal intelligence, nonverbal intelligence and full scale intelligence can be obtained from the test; however only the verbal and nonverbal quotients were used in this study. Based on United States correlational studies, the Canadian Lorge Thorndike Intelligence Test, Verbal

Scale correlates in the high .70's and .80's with other well known measures of intelligence; principally the Stanford-Binet Intelligence Scale and the Wechsler Intelligence Scale for Children, Verbal Scale. The nonverbal scale correlates somewhat lower with these tests and is reported to be in the high .60's and .70's (Lorge, Thorndike and Hagen, 1967:29). Odd-even reliability data, based on derived test scores from single grade representative samples, show a correlation of .612 between the verbal and nonverbal batteries (Lorge, Thorndike and Hagen, 1967:29). This is very similar to the correlation of .627 reported for the more proficient readers and the correlation of .522 reported for the less proficient readers in verbal and nonverbal performance in this study.

### Concrete (CCO) and Stories (SCO)

These tests of the logical operations of classification were primarily based on instruments constructed by Rawson (1969: 326-338). However a number of revisions and additions were made. These will be specifically discussed in Chapter V. The test questions CCO, and the test questions SCO, including the stories, are in Appendices A to F. The materials for the concrete tasks were based on the criteria stipulated by Rawson (1969:141-142) and were constructed by the researcher.

### Digit Span Subtest

The Digit Span Subtest of the Wechsler Intelligence Scale for Children, Revised (WISC-R), 1974 was used as a screening test for immediate recall. In the initial segment of the test, the subject was required to recall and repeat, in order, series of digits ranging from three to nine numbers in length. The digits were presented verbally by the researcher. During the remaining segment of the test the subject was again presented with series of digits and was required to recall them in a reverse order. These series ranged from two to eight digits in length.

The total score of the subject was calculated by adding both the number of series of digits forward and the number of series of digits recalled backwards correctly by the subject. This total score was then converted to a scaled score based on age. The age norms were provided by the author of the test (Wechsler, 1974:133-136). This subtest is in general a poor measures of general intelligence, however it is a measure of attention and short term memory (Sattler, 1974:534; Rapaport, Gill and Schafer, 1968:111; Taylor, 1961:434).

## THE TREATMENT PROCEDURE

The majority of the New Developmental Reading Tests were administered by the classroom teachers of the subjects in the study during October 1976. In addition 60 more subjects were assessed in January 1977. The experimental tests, concrete and reading tasks of classification, were administered to the subjects from February 21, 1977 to March 25, 1977. A randomization procedure was conducted for both schools and individual subjects. The five schools involved in the study were randomly ordered. Then all the subjects in each school, who were involved in the study, were randomly assigned to the treatments.

In addition, seven major classification tasks were randomized for all the subjects (Fisher and Yates, 1953:115-119). Total testing time per subject was approximately 75 minutes. The general instructions and the details of the specific activity will be described in the next chapter. All interviews were tape-recorded and later transcribed on specific code sheets. The code sheets corresponded directly to the subtest and subtest item.

## Pilot Study

The purpose of the pilot study was to:

1. Test and assess the clarity and completeness of the materials and instructions presented for the test items.

2. Obtain an indication of the time required to administer the tests.

3. Determine the appropriateness of the scoring criteria in assessing the responses.

Five less and five more proficient readers were randomly selected from the total sample of 50 subjects and assigned to complete the nine tasks. The total sample was selected according to the second criterion (see page 96).

The pilot study was conducted during the last week in January 1977 and the first two weeks of February 1977. As described for the main study the test interviews were tape-recorded and transcribed.

As a result of test performance, a number of adjustments and changes were made:

1. The total number of subtests were reduced from nine to seven. This reduction was necessary because of the long testing time required

to administer all the subtest items. It was felt the time required to administer the additional test items was out of proportion to the information obtained. The two test items consisted of multiplicative classification tasks, matrix and intersection in the reading situation. The matrix classification task required an additional 20 minutes to administer. It was felt by the researcher that to retain this item would have contributed substantially to the total testing time and to the individual subject fatigue factor. The intersection question was omitted primarily because this item did not appear to differentiate between the two groups. It was felt by the researcher that this problem could be solved principally on the basis of the subject's personal experience and reliance on the logical operations would be minimal. This item, in essence, did not meet Rule 2 as specified on pages 117-118.

2. Subjects also found a number of the items confusing; subsequently changes were made in some questions and instructions.

3. In an attempt to score the protocols it became clear that a more specific criterion for evaluating and assessing the responses was required. The specific criteria adopted will be discussed in Chapter V. The protocols of the pilot study were rescored. On the basis of the readjusted criteria, the analysis of the results suggested that the two groups tended to differ in their general test performance.

4. It was also noted by the researcher that the criterion used for the selection of the two groups, more proficient readers and less proficient readers, was insufficient. The criterion did not

permit the researcher to clearly identify the two groups.

## Readability Levels of the Stories

The readability levels of each of the four stories was estimated using the Dale-Chall Readability Formula (Dale and Chall, 1948:39; Klare, 1963:60; Klare, 1975:70). The Dale-Chall Readability Formula, which is a count of word and sentence length, is considered by Klare to be a relatively good predictor of readability (Klare, 1975: 97). The calculations of the level were based on the complete story text. The grade placement of all subjects tested was six years six months.

The assessment of the readability levels and corrected grade levels of the stories presented, suggests that all the stories were below the grade placement of the children in the study (see Table 10). To ensure as much as possible that errors in word identification and literal comprehension did not contribute significantly to the subjects' performance in logical operations of classification required in the study, the following procedure was adopted:

1. All subjects were required to answer a series of literal comprehension questions after they read each story silently. If the response to a question was incorrect the subject was required to reread that segment of the text, and attempt to answer the question again.

2. The subject was instructed to ask for assistance if he was experiencing difficulty in decoding. It should be noted that assistance required here was negligible.

Table 10

Levels of Readability of the Stories in the Stories Test of Classification as Predicted by the Dale-Chall Readability Formula

| Story | Average Sentence Length in Words | Dale Score | Readability Grade Score | Corrected Grade Levels |
|---|---|---|---|---|
| Story I The Ducks Arrive in Spring | 12 | 5 | 5.02 | 5-6 |
| Story II Jim and his Garden | 17 | 5 | 5.18 | 5-6 |
| Story III A City of Long Ago | 12 | 1 | 4.39 | 4 or less |
| Story IV The Twins | 12 | 7 | 5.28 | 5-6 |

## Reliability of the Scoring

Three markers, the investigator, and two graduate students from the University of Alberta, one a PhD student in Elementary Education (Reading), and the other a PhD student in Educational Psychology, scored independently, the protocols of a random sample of four subjects. The Arrington Formula was used and coefficients of agreement were calculated.

$$\frac{2 \times \text{agreements}}{2 \times \text{agreements} + \text{disagreements}}$$

(Feifel and Lorge, 1950:5)

Table 11

Percentage of Agreement of Judges 1, 2 and 3

| Judges | Agreement |
|---|---|
| 1,2 | 96% |
| 1,3 | 96% |
| 2,3 | 96% |

The assessment of the results of Table 11 would suggest that the criteria for scoring the protocols could be applied independently with reasonable uniformity.

## Validity of the Concrete and Stories Tests of Classification

This section will discuss the validity of the test items in two general areas:

1. The validity of the design for assessing the logical operations, and the construct validity of the items.

2. The validity of the test situations selected, for assessing the logical operations of classification.

Validity of the Design of the Test Items. Smedslund (1964:4) in his studies of children's reasoning proposed seven methodological rules that should be applied in the construction of test items in an attempt to maximize the diagnostic validity of the test items. These rules were adopted by Rawson (1969:95) in her original study and will also be adopted in this study.

Rule 1. The child should not be able to solve the problems in terms of perceptual processes alone. This can be assured if the initial events are absent at the moment of solution (Smedslund, 1964: 4).

With direct reference to the research instrument in this study, the concrete test items were covered during the initial presentation of the test questions.

In the story tests preliminary questions were designed, and asked, to ensure that the subjects had decoded efficiently and understood the text at a literal level. Solutions to the specific test items were not given in the text of the story, thus the questions could not be solved strictly on the basis of decoding and recall. Both situations would require a decision, and an anticipatory schema.

Rule 2. The child should not be able to solve the problem intuitively in terms of readily available hypotheses with a non-logical structure (Smedslund, 1964:4).

This rule primarily applies to the construction of test items in such a manner that a logical operation is required to solve the problem. However, the task cannot be solved through a non-logical operation, which is available from experience. The extent to which children were relying on logical and non-logical operations in solving the tasks was assessed through their explanations of the decisions used in solving the tasks.

Rule 3. The possibility of guessing the correct answers should be minimized (Smedslund, 1964:4).

To meet this criterion, the subject had to provide both a correct decision and a correct explanation of the decision to obtain a score on the test items.

Rule 4. Verbally communicated hypothetical premises should be avoided. Essentially all the information which is available to the subject should be in the form of perceived events (Smedslund, 1964:4).

In direct relation to the experimental tasks, the material in the concrete items was directly available to the subject. In the story items the items of information were read and recalled as read. Hypothetical premises of the form, if . . ., then were not present in any of the reading or concrete stimuli (Rawson, 1969:98).

Rule 5. The subjects must have initially perceived the relevant events (Smedslund, 1964:4).

In the concrete tasks the subject was required to label the material, and in the reading task the subject was required to answer a number of preliminary literal memory comprehension questions. If the subject was not successful in answering the literal questions he was required to reread orally the segment of the passage which contained the correct information. Furthermore, in each situation a "set" was suggested to the subject, which indicated that the relevant information required to complete the task would be the observed and reported facts and conditions.

In terms of the multiplicative test items, the required information essential to successful completion of the task was repeated if the initial response was incorrect.

Rule 6. Differential reinforcement should be avoided by providing every response with the same mild positive reinforcement (Smedslund, 1964:4).

Differential reinforcement was avoided during the testing situation by accepting any response as the opinion of the subject, and by requiring an explanation for both correct and incorrect decisions. In addition the child was only queried if the information provided was insufficient to permit correct evaluation of the response.

Rule 7. Material type should be similar and constant in order to control for the material type effect (Smedslund, 1964:4).

In an attempt to meet this criterion of percept constancy, the concrete stimulus materials were kept as uniform as possible for all the test items. In the reading situation, one story situation was, in general, the unit for testing each subtask of the logical operation of classification.

Constancy between concrete and reading situations was maintained by primarily relying on stimuli which was considered to be familiar to the subjects and was within the subjects' realm of experience.

In general it is considered that these rules or principles have been satisfactorily followed in designing the concrete and stories tests.

In an attempt to diagnose the presence versus the absence of concrete reasoning in both the reading and concrete situation, the following three criteria were adopted from Smedslund (1964:4):

1. The initial events are perceived by the subject. In the concrete situation, if the counters were to be covered, the subject was requested to describe the counters, and in the reading situation the subject was requested to answer a series of literal comprehension questions.

2. The objects or events are removed. This criterion was met by covering the concrete objects, and requesting a preliminary explanation before the subject physically manipulated the counters. In the reading situation, the stories were removed before the subject was asked the reasoning questions.

3. The events have one necessarily acceptable conclusion. The conclusions or correct responses were prescribed in the criterion for both the reading and concrete situation. If the response was considered acceptable in a situation, concrete or reading, it was assumed that the subject was capable of concrete reasoning and performing the concrete operation of classification in that situation.

Construct Validity of the Test Items. Two important questions must be considered in assessing the construct validity of the test items used to measure the logical operations of classification.

1. To what can the measures of the logical operations of

classification be related?

2. To what extent do the test items represent the logical operations of classification? (Rawson, 1969:101; Thorndike and Hagen, 1961:172)

To match the tasks of the tests, Rawson (1969:101) notes that a possible technique would be to use the symbolic descriptions devised by logicians to assess the structure of the logical operations under study. These logical operations are represented by logicians in symbolic form. In essence, logicians rely on symbolic notation to abstract form from content. Construct validity of a test item can be determined by assessing the extent of the correspondence of the task's symbolic representation to the accepted logical representation of the same operation.

For instance, the construct validity of tasks involving class inclusion would be considered acceptable if they conformed directly to the following recognized principle.

$$(\hat{F} \subset \hat{G}) \supset x: (x \varepsilon F) \text{ and } (x \varepsilon G)$$

If the class F is a subset of class G then x is a member of class F and x is also a member of class G (Rawson, 1969:101).

An attempt will be made in Chapter V to judge the construct validity and comparability of the concrete and story test items by this procedure. The procedure will be directly based on Rawson's (1969:154-163) procedure.

Essentially, since construct validity is based on a judgement that a symbolic representation of a task is identical with the logical operations as described by logicians, one cannot assume that the subjects' thinking which yields logical solutions is identical with the symbolic representations. As Rawson (1969:102) suggests, the subjects' justifications presented for a logical conclusion will refer to the classes and relations, which can be represented by the logical symbols. However, the cognitive processes involved in the subject's thinking (which is not observable) and the verbal statements justifying his conclusions may very well follow a very different sequence and procedure.

## Validity of the Test Situation

The validity of the test situation was related directly to the degree of continuity that had been maintained between this study and previous studies, in the development of the logical operations of classification. The situations for testing the concrete operations of classification were directly adopted from Rawson (1969). However a number of slight modifications were made. These will be discussed in Chapter V. Rawson adopted the concrete testing situations from tests originally designed by Piaget and Inhelder (1964) and Smedslund (1964). It is considered that even with minor modifications the concrete tests of classification still closely parallel the earlier studies of Rawson (1969), Smedslund (1964) and Piaget and Inhelder (1964).

According to Rawson (1969:105), the validity of the story's test situation is dependent upon the comparability of these test items with the same test items in the concrete situation. In essence, the forms of reasoning required by the concrete and story tests of classification should be of the same form as identified in scholarly works of logic, dealing with the logical operations of classification.

The corresponding test items should be comparable in form as distinct from content. This will be discussed more specifically in Chapter V.

## ANALYSIS OF THE DATA

The data for analysis were obtained from transcribed tape recordings of the testing conditions with each of the subjects. The programs for the statistical procedures for the analysis of the data were obtained from the Division of Research Services, Faculty of Education, University of Alberta.

Two, two factor analyses of variance, groups factor A and classification tasks factor B, with repeated measures on factor B, were conducted to assess the extent to which the two groups differed in their performance of the classification tasks (Winer, 1971:525-539). The Newman-Keuls procedure was used for the multiple comparison of means.

In addition, Hotelling's $T^2$ Test and Welch's t test were used to assess the extent of the group differences on the four classification tasks (Morrison, 1967:117; Ferguson, 1971:155). Pearson product-moment correlation coefficients were obtained between the following scores for each group of readers: Additive Classification Concrete, Additive Classification Reading, Multiplicative Classification Reading, Multiplicative Classification Concrete, verbal IQ, nonverbal IQ, Literal Comprehension score on the stories tests of classification, vocabulary score (BBH), Literal Comprehension score (BBH), Creative Comprehension score (BBH), and rates for stories I, II, III and IV.

Welch's t test was used to determine whether the means of the two groups differed significantly in the following areas: verbal IQ, nonverbal IQ, Literal Comprehension Stories tests of classification, vocabulary (BBH), Literal Comprehension (BBH), Creative Comprehension (BBH), and digit span.

## SUMMARY

This chapter has presented a discussion of the design of the study, the student population and the selection of the sample. The screening tests and the research instrument were also briefly described. Included in this discussion were the pilot study and resulting revisions, the predicted readability levels of the stories, the validity of the research instrument and the statistical procedures used for the analysis of the data.

# CHAPTER V

# THE RESEARCH INSTRUMENT

This chapter will describe the research instrument, its further development, the dimensions of classification measured, and the materials used in this study. A discussion concerning the comparability of the test items will follow and the chapter will conclude with a summary of the scoring criteria used to assess the subjects' responses and explanations.

## DESCRIPTION OF THE RESEARCH INSTRUMENT

The major components of the research instrument were devised by Rawson (Rawson, 1969:140-163). Rawson's research instrument was in turn adopted from experiments designed by Piaget and Inhelder (1964:59-99) and Smedslund (1964:8-11). This consisted of the test items in the concrete situation and the two major test items in the reading situation. In an attempt to further assess the operations of classification in the reading situation, two additional test items were constructed by the researcher. Although the majority of the other test items were adopted in their original form, changes and revisions were made to a number of the test items in an attempt to further clarify the tasks.

Essentially, the test instrument used in this study consisted of two parts, a reading component (SCO) and a concrete component (CCO). The reading component of the instrument consisted of four passages and the corresponding test questions, and the concrete component consisted of a set of counters, supports and rods and the corresponding test questions. These components were designed to assess, in general, the two primary aspects of classification, additive classification and multiplicative classification, and specifically the five major dimensions of classification. These major dimensions will be discussed in the next section.

## Purpose of the Research Instrument

The research instrument was designed to assess, in general, two major aspects of classification, additive classification and multiplicative classification, and specifically five major dimensions of classification. These major dimensions are:

1. Abstracting critical properties which define membership in a class (Construction of Classes).
2. Inferring class inclusion relations (Class Inclusion).
3. Constructing predicates which describe the extension of dichotomous classes (Predicates).
4. Constructing and ordering multiplicative classes (Matrix Structure).
5. Constructing simple multiplicative classes (Intersection).

## Materials

This section will discuss and describe the materials used to assess the five major dimensions of classification.

### Class construction and class inclusion (Additive Classification).

In the concrete situation the following materials were used:

6 square black plasticized display supports, size 23 cm

10 red round plastic counters, diameter 2.5 cm

3 yellow round plastic counters, diameter 2.5 cm (removed for class inclusion)

3 red square plasticized counters, size 2.5 cm

3 yellow square plasticized counters, size 2.5 cm.

(See Figure 15)

In the reading situation, Story I, The Ducks Arrive in Spring, was used (Appendix A).

Predicates (Additive Classification). The following materials were used to assess this dimension of classification in the concrete situation:

2 yellow square plasticized counters, side 2.5 cm

2 red square plasticized counters, side 2.5 cm

2 yellow square plasticized counters, side 1.5 cm

2 red square plasticized counters, side 1.5 cm

2 yellow round plastic counters, diameter 2.5 cm

2 red round plastic counters, diameter 2.5 cm

2 yellow round plastic counters, diameter 1.5 cm

2 red round plastic counters, diameter 1.5 cm

2 large black round plasticized supports, diameter 23 cm

2 large black square plasticized supports, side 23 cm

2 white cardboard rods, 23 cm long and 5 mm wide. (See Figure 16)

Story I, The Ducks Arrive in Spring, was used to assess this dimension of classification in the reading situation (Appendix A).

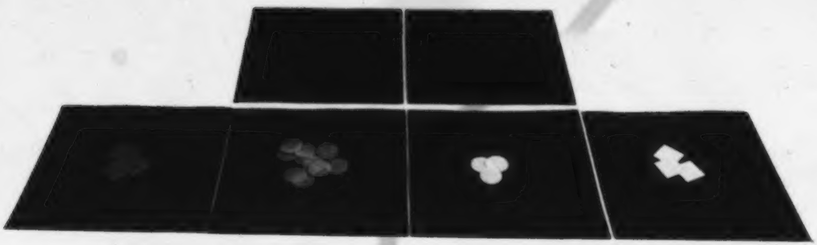


Figure 15

Test Materials: Class Construction and Class Inclusion

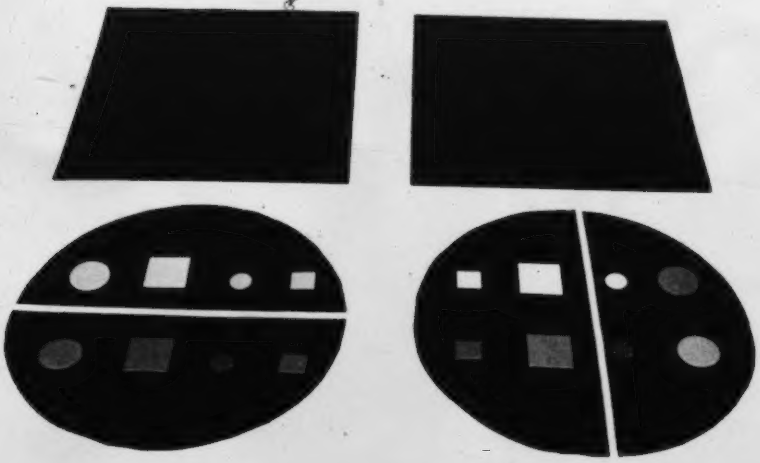


Figure 16

Test Materials: Predicates: Patterns I and II

Matrix structures (Multiplicative Classification). The following materials were used to assess the dimension of multiplicative classification matrix structure, concrete situation:

10 red round plastic counters, diameter 2.5 cm

3 green round plastic counters, diameter 2.5 cm

3 red square plasticized counters, side 2.5 cm

3 green square plasticized counters, side 2.5 cm

2 large black square plasticized supports, side 23 cm

2 white cardboard rods, 23 cm long and 5 mm wide. (See Figure 17)

Story I, The Ducks Arrive in Spring and Story II, Jim and his Garden were used to assess this dimension of classification in the reading situation (Appendix A and B).

Intersection (Multiplicative Classification). The following materials were used to assess the dimension of multiplicative classification, intersection in the concrete situation:

5 green square plasticized counters, side 2.5 cm

5 green round plastic counters, diameter 1.5 cm

2 green round plastic counters, diameter 2.5 cm

2 green square plasticized counters, side 2.5 cm

1 black square plasticized counter, side 2.5 cm

3 green square plasticized counters, side 1.5 cm

1 red square plasticized counter, side 1.5 cm

1 black square plasticized counter, side 1.5 cm

1 green round plastic counters, diameter 1.5 cm

1 red round plastic counter, diameter 1.5 cm

2 large black square plasticized supports, side 23 cm

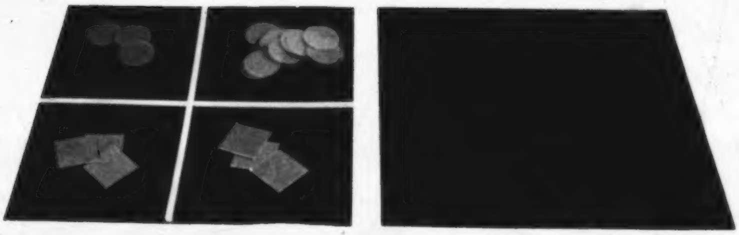


Figure 17

Test Materials: Matrix Structures

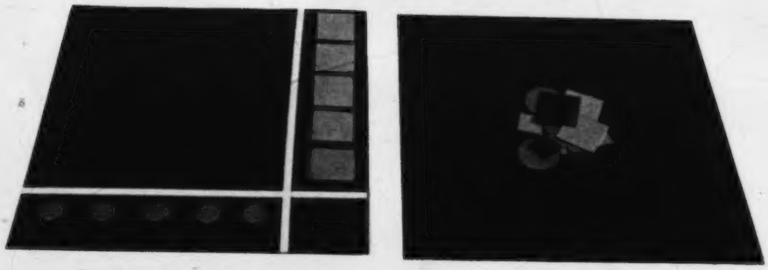


Figure 18

Test Materials: Intersection, Pattern III

2 white cardboard rods, 23 cm long and 5 mm wide.

(See Figure 18)

The stories A City of Long Ago (Story III) and The Twins (Story IV) were used to assess this dimension of classification in the reading situation.

## Preliminary Questions

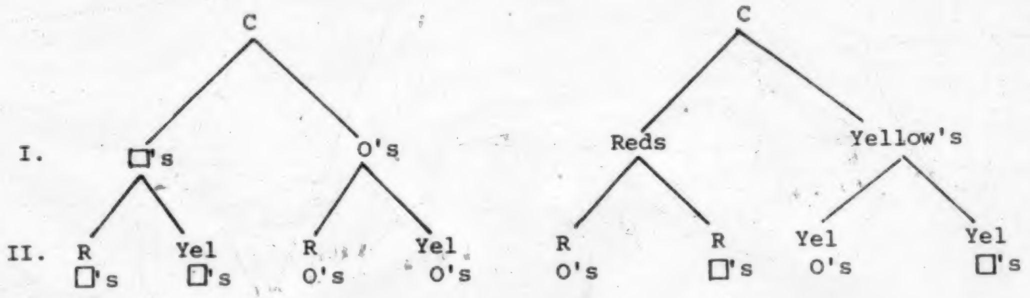
A series of preliminary questions, twelve for story I, five for story II, seven for story III, and six for story IV were used to ensure literal comprehension of the material. These questions were also used in an attempt to assess the subjects' recall of basic literal information (see Appendixes A, B, C, and D). The questions for stories I and III were directly adopted from Rawson's instrument, and the questions for stories II and IV were developed by the researcher. All questions appear to reasonably correspond to the knowledge and comprehension levels as specified by Hunkins (1976:19). In general these questions required the subjects to recall, translate and interpret the specific details they read (Hunkins, 1976:20).

## COMPARABILITY OF CONCRETE AND STORIES TESTS: ADDITIVE CLASSIFICATION

## Construction of Classes

The test items used to assess the dimension abstraction and membership in a class in a concrete situation, and in the reading situation are summarized in Figure 19 and presented in Appendix A and E. Questions I and II (CCO) were directly adopted from Rawson's

Concrete (CCO)


C
I.
□'s
O's
II.
R
□'s
Yel
□'s
R
O's
Yel
O's
C
Reds
Yellow's
R
O's
R
□'s
Yel
O's
Yel
□'s

Reading (SCO)

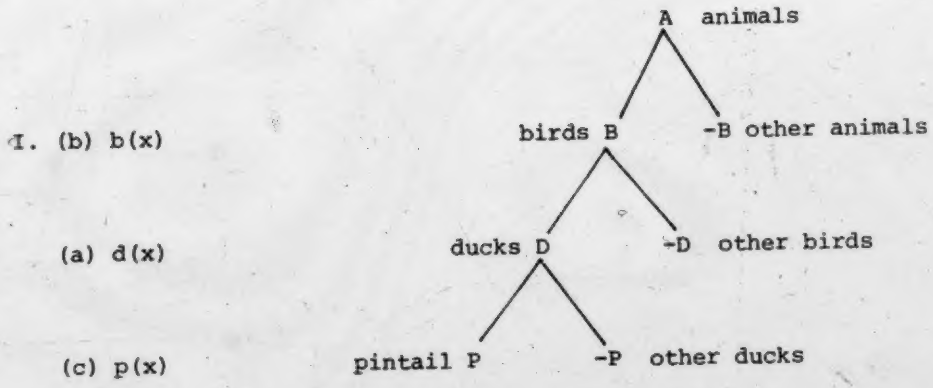

A animals
I. (b) b(x)
birds B
-B other animals
(a) d(x)
ducks D
-D other birds
(c) p(x)
pintail P
-P other ducks

Figure 19

Summary of Test Items, Concrete and Reading Situation.
Major Dimension Abstraction and
Membership in a Class

instrument and questions. Questions I a,b,c (SCO) were developed in an attempt to further assess this dimension of classification, in the reading situation. The specific view accepted for questions I a,b,c (SCO) was adapted from Fenker and Tees (1976:340).

The test items I and II in the concrete situation required the subject to abstract the specific properties, shape and color, from a collection of counters presented to them. They then had to place the counters into two and four mutually exclusive and exhaustive classes.

The corresponding test items, I a,b,c, in the reading situation required the subjects to recognize and verbalize the major properties of the classes birds (x):b(x); ducks (x):d(x); and pintails (x):p(x). The properties b, d and p defined by the subject had to allow the construction of three mutually exclusive and exhaustive classes. Essentially, the subjects had to state how a subordinate class was distinct from a superordinate class, and how the subordinate and superordinate classes were related.

In the concrete situation the criterial properties were defined by the specific perceptual attributes elicited by the counters (shape: square, round; and color: red, yellow). In the reading situation a number of the criterial properties were defined in the story, however the subject also had to rely on background experience to define a number of the other properties.

Rawson notes that these two test situations appear to be directed towards a common dimension of classification. This dimension is principally the abstraction of criterial properties and the assigning of membership in a class on the basis of these defining properties (Rawson, 1969:155).

## Class Inclusion

The test items CCO and SCO, used to assess class inclusion relations, are based on the class structures presented in Figure 20 and Figure 21.

In this testing situation the formation of the two major kinds of hierarchies may not necessarily be of equal difficulty. In essence, the concrete class structure presents the empty class and the story class structure presents the complementary class.

In general, there are two further differences that may affect the performance of the subjects in the two situations.

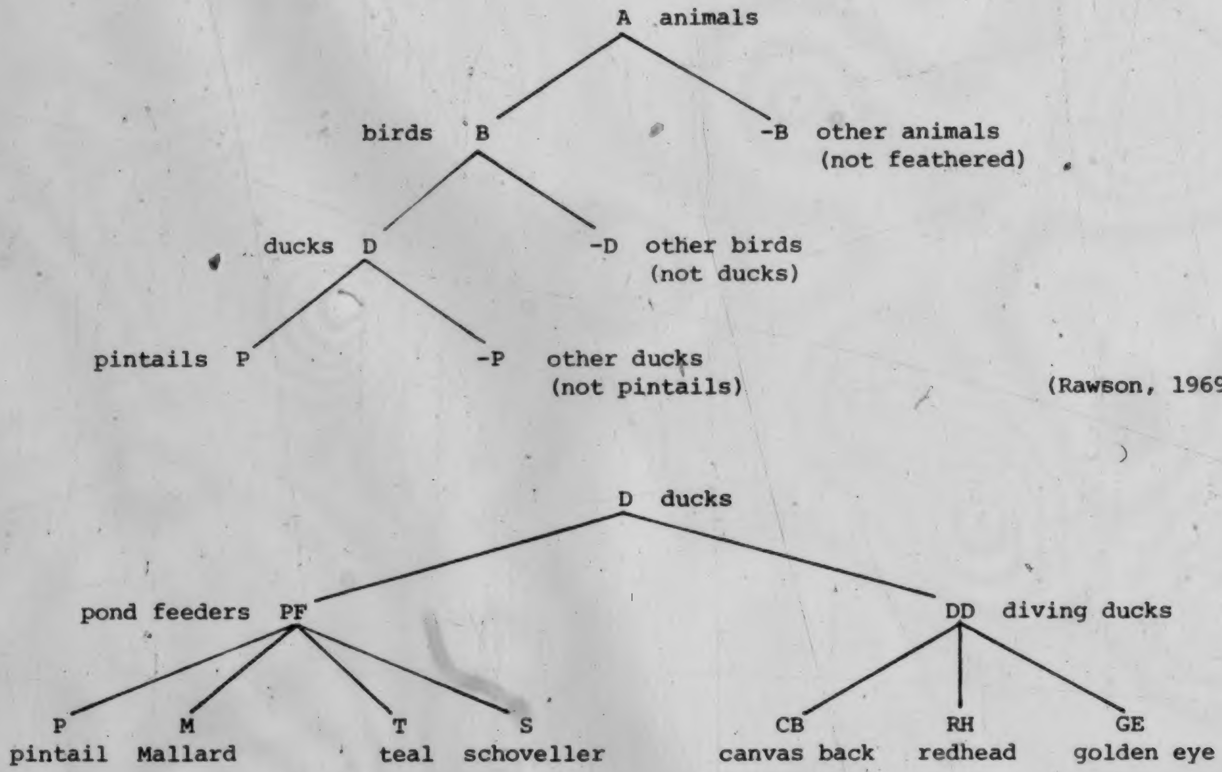
First, there is the manner of presentation of the information related to inclusion, and the extent to which the subject must rely on background knowledge to restructure the information.

e.g. The first birds to arrive are ducks and the first ducks are pintails.

Second, the universe of discourse is frequently more explicit in a concrete situation than in a reading situation. In a concrete situation the universe of discourse is stated explicitly, and the subject can see and manipulate the concrete items.

e.g. "These are counters."

However, in a reading situation the universe of discourse is less explicitly stated and may have to be inferred by the reader. Specifically in the story The Ducks Arrive in Spring the subject had to infer the universe of discourse, the world of animals, their habits and


A animals
birds B
-B other animals (not feathered)
ducks D
-D other birds (not ducks)
pintails P
-P other ducks (not pintails)
D ducks
pond feeders PF
DD diving ducks
P pintail
M Mallard
T teal
S schoveller
CB canvas back
RH redhead
GE golden eye

(Rawson, 1969:55)

Figure 20

Hierarchical Class Structure: (a), (b)
Class Inclusion Relations SCO

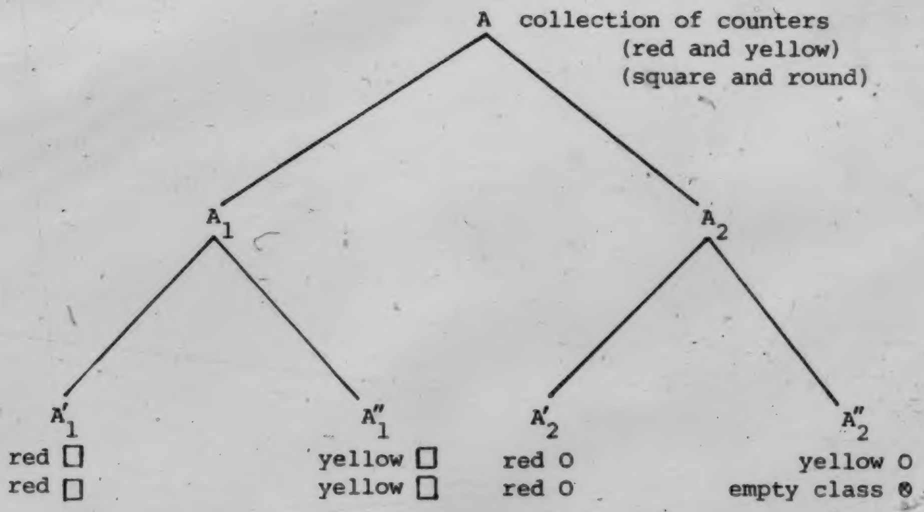

A collection of counters
(red and yellow)
(square and round)
$A_1$
$A_2$
$A'_1$
red □
red □
$A''_1$
yellow □
yellow □
$A'_2$
red ○
red ○
$A''_2$
yellow ○
empty class ⊗

Figure 21

Hierarchical Class Structure: Class Inclusion Relations CCO habitats. The reader had to form inclusion relations within this context. However, an attempt was made by the researcher to make the universe of discourse more explicit by providing the reader with a thematic statement as to what the passage was about.

For example, the passage The Ducks Arrive in Spring was introduced to the reader by the following statement: "This is a story about the ducks that fly to the prairie in the spring. The story is also about the birds that come to the lakes and ponds of the prairie in the spring."

In addition, the six additional inclusion questions, devised by the researcher, were directly related to the information provided by the passage.

As Rawson suggests, the problems of restructuring data and determining and inferring the universe of discourse is inherent in reading comprehension (Rawson, 1969:156). It is conceivable that this problem may be specifically inherent in the higher levels of thought involved in reading comprehension.

It is noted by Rawson and supported by the researcher that these are considered to be reasonable differences between the concrete and reading situations (Rawson, 1969:156).

The comparability of the concrete test items III and IV and the corresponding story items II and III are presented and may be examined in Figure 22.

The general logical form of questions III and IV CCO, and II and III SCO is:

| | CCO | SCO |
|---|---|---|
| Item | $\underset{R}{\square}$ $\underset{Y}{\square}$ $\underset{R}{O}$ $\otimes$ | Story: The Ducks Arrive in Spring |
| III. | More R's . . . or more O's | II. More ducks or more pintails? Are pintails ducks? |
| | $\hat{x}R = \hat{x}\,\overset{R}{\square} + \overset{R}{O}$ | $\hat{x}D = \hat{x}P + \hat{x}(-P)$ |
| | $\hat{x}R > \hat{x}\overset{R}{O}$ | $\hat{x}D > \hat{x}P$ |
| | $\hat{x}\overset{R}{O} \subset \hat{x}R$ | $\hat{x}P \subset \hat{x}D$ |
| IV. | Are all the □'s R? | III. More animals or more birds? Are birds animals? |
| | $\hat{x}\square = \hat{x}\overset{Y}{\square} + \hat{x}\overset{R}{\square}$ | $\hat{x}A = \hat{x}B + \hat{x}(-B)$ |
| | $\hat{x}\square > \hat{x}\overset{R}{\square}$ | $\hat{x}A > \hat{x}B$ |
| | $\hat{x}\overset{R}{\square} \subset \hat{x}\square$ | $\hat{x}B \subset \hat{x}A$ |

Figure 22

Class Inclusion Comparability of Test Items III, IV CCO and II, III SCO
(Rawson, 1969:157)

$B = A + A'$

$B > A$

A C B

($A'$ = another subclass that comprises the superordinate class B) (Rawson, 1969:157).

However, there is a difference between the CCO and SCO items. The SCO test items primarily deal with the complementary class (-A), whereas the CCO items deal with another subclass $A'$. The generalized form of the SCO items is:

$B = A + (-A)$

$B > A$

A C B

(-A) = other B which do not have the primary attribute of A.

(Regretably an error was made in this segment of the study by the present researcher. Question II SCO as devised by Rawson (1969: 328) was omitted. This was:

II. (Rawson) Are there more ducks or more birds on the prairie in the summer? Are ducks birds? However it was assumed that question II (SCO) as adopted by the researcher was equivalent to question II (Rawson) and therefore comparable to question IV CCO:

III. (SCO) Are there more animals or more birds in the world? Are birds animals?

The comparability of the items V, IX, X CCO and items III, IV, VIIIe, VIIIf SCO are presented and may be examined in Figure 23. Items V, IX, X CCO and items III and IV were directly adopted from Rawson (1969:329,332). Items VIIIe, and VIIIf were constructed by the researcher in

CCO

Item $\overset{R}{O}$ $\overset{R}{\square}$ $\overset{Y}{\square}$ $\otimes$

V. Are all the Y's . . . $\square$?

$$\hat{x}Y = \hat{x}\overset{Y}{\square} + \otimes$$

$$\hat{x}Y = \hat{x}\overset{Y}{\square}$$

$$\hat{x}Y \subseteq \overset{Y}{\square}$$

IX. If x is yellow will it have to be square?

$$\hat{x}Y = \hat{x}\overset{Y}{\square} + x\otimes$$

$$\hat{x}Y \subseteq \hat{x}\overset{Y}{\square} + x\otimes$$

X. If x is round will it have to be red?

$$\hat{x}O = \hat{x}\overset{R}{O} + \hat{x}\otimes$$

$$\hat{x}O \subseteq \hat{x}\overset{R}{O}$$

SCO

The Ducks Arrive in Spring

III. Are there more animals or more birds? Are birds animals?

$$\hat{x}A = \hat{x}B + \hat{x}(-B)$$

$$\hat{x}A > \hat{x}B$$

$$\hat{x}B \subset \hat{x}A$$

IV. If all the birds flew away would there be some ducks left?

$$\hat{x}B = \hat{x}D + \hat{x}(-D)$$

$$\hat{x}B \subseteq \hat{x}D + \hat{x}(-D)$$

VIIIe If x is a teal would the duck have to be a pondfeeder?

$$\hat{x}PF = \hat{x}P + \hat{x}M + \hat{x}T + \hat{x}S$$

$$\hat{x}T \subset \hat{x}PF$$

VIIIf If x is a canvas back would the duck have to be a diving duck?

$$\hat{x}DD = \hat{x}CB + \hat{x}RH + \hat{x}GE$$

$$\hat{x}CB \subset \hat{x}DD$$

Figure 23

Class Inclusion: Comparability of Test Items V, IX, X CCO and III, IV, VIII e,f SCO
(Rawson, 1969:158,159)

an attempt to make the two situations more equivalent both in number and in the inclusion relations the subjects were required to perform.

All these items in Figure 23 assess complete class inclusion. According to Rawson, it was necessary to use the empty class in the concrete situation in an attempt to assess this component of inclusion relations (Rawson, 1969:158). However, there is an essential difference between these items. The outcome for CCO V, IX and X is complete class inclusion. In this case, every A is a B and every B is an A, therefore A and B are coextensive. In the test item SCO III the outcome is also complete class inclusion, however the class B is not coextensive with the class A primarily because every A is not a B, even though every B is an A. (See Complete Class Inclusion, Chapter I, p. 13.) Since the class B is coextensive with the classes D and -D in test item SCO IV, this test item is considered to be more comparable to test item CCO IX.

The generalized logical forms of these test items are as follows:

CCO $B = A + \otimes$ SCO $B = A + (-A)$

$B = A$ $B > A$

$B \subseteq A$ $B \subset A$

(Rawson, 1969:159)

The distinction between these items is the exclusive use of coextensive relations in the concrete situation and the use of both coextensive and not coextensive relations in the reading situation. However, all the inclusion relations between classes are relations between the extension of classes; specifically, in this case, in the extension of subclasses and of a superordinate class. Principally, the difference between the two conditions is the structures of the classes to be related. The empty class was utilized in the CCO test items, and the complementary class in the SCO test items. However, both conditions deal with the inclusion relations between classes and are, in general, considered equivalent.

Items VI, VII and VIII CCO were constructed by Rawson (1969:332) and items VIIIa, VIIIb, VIIIc and VIIId were constructed by the researcher. The comparability of these items can be examined in Figure 24. All the items measure class inclusion relation and involve the quantifier "some." The items are considered comparable except for the number of subclasses dealt with in each case. The concrete items dealt primarily with two subclasses, while the story items dealt with three in one case and four in the other.

In general, as Rawson (1969:160) suggests, the inclusion relations measured by the two situations, reading and concrete, are similar in the generalized form. Essentially, the items assess the subject's performance in forming additive relations between subclasses and superordinate classes and the quantification of the relation between a superordinate class and its subclasses. The differences observed principally relate to the characteristics of the subclasses: the empty class in the concrete test items and the complementary class in the story test items.

## Predicates

Test items XI, XII and XIII CCO and items V, VI and VII SCO were adopted from Rawson's (1969:329,333) instrument to assess the

| CCO | SCO |
|---|---|
| Item $\overset{R}{O}$ $\overset{R}{\square}$ $\overset{Y}{\square}$ ⊗ | The Ducks Arrive in Spring |
| VI. Are some of the R's . . . O's?<br>$\hat{x}R = \hat{x}\overset{R}{O} + \hat{x}\overset{R}{\square}$<br>$(\exists x):(x\varepsilon R) \supset (x\varepsilon O)$ | VIII(a) Are some of the pond feeders mallards?<br>$\hat{x}PF = \hat{x}P + \hat{x}M + \hat{x}T + \hat{x}S$<br>$(\exists x):(x\varepsilon PF) \supset (x\varepsilon M)$ |
|  | VIII(b) Are some of the diving ducks red heads?<br>$\hat{x}DD = \hat{x}GE + \hat{x}RH + \hat{x}CB$<br>$(\exists x):(x\varepsilon DD) \supset (x\varepsilon CB)$ |
| VII. If x is a □ must it be R?<br>$\hat{x}\square = \hat{x}\overset{R}{\square} + \hat{x}\overset{Y}{\square}$<br>$(\exists x):(x\varepsilon\square) \supset (x\varepsilon Y)$ | VIII(c) If x is a diving duck will it have to be a canvas back?<br>$\hat{x}DD = \hat{x}GE + \hat{x}RH + \hat{x}CB$<br>$(\exists x):(x\varepsilon DD) \supset (x\varepsilon CB)$ |
| VIII. If x is an R must it be O?<br>$\hat{x}R = \hat{x}\overset{R}{O} + \hat{x}\overset{R}{\square}$<br>$(\exists x):(x\varepsilon R) \supset (x\varepsilon\square)$ | VIII(d) If x is a pond feeder will it have to be a pintail?<br>$\hat{x}PF = \hat{x}P + \hat{x}M + \hat{x}T + \hat{x}S$<br>$(\exists x):(x\varepsilon PF) \supset (x\varepsilon P)$ |

Figure 24

Class Inclusion: Comparability of Test Items VI, VII, VIII CCO and VIII a,b,c,d SCO
(Rawson, 1969:159)

construction of predicates. These predicates describe the extension of dichotomous classes. The concrete items were used in their original forms as constructed by Rawson (1969), however the story items were altered slightly. The alterations consisted of adding "all" and substituting "groups" for "kinds" to the general question. In addition, there was also the addition of a brief statement (Q) to be used only if the subject was not able to answer the initial question correctly.

e.g. V. I want you to tell me about the kinds of ducks that come to the prairie. Put the ducks you read about into two different kinds or lots. You can do this without using their names. Describe them.

What would be two kinds of ducks that come in the spring? Describe them.

If the response is a list of names, the examiner replies: Can you describe them? What kind of ducks come back in the spring? Put them into "two" lots. (Rawson, 1969:329)

Changed to: V. I want you to tell me about the "kinds" of ducks that come to the prairie. Put all the ducks you read about into two different groups or lots. You can do this without using their names. Describe them.

(Q) Divide all the ducks that come back into two groups, and describe the groups.

If the response is to list names, the examiner replies: Can you describe them? What groups of ducks come back in the spring? Put them all into two lots.

It was felt by the researcher that these changes did not significantly distract from the essence of the original questions, devised by Rawson (1969), but may have contributed to the further clarification of the test items. Essentially, the subject was informed that he had to deal with groups, as opposed to just describing the ducks.

The concrete test items were based on Patterns I and II (see Figure 16), while the story test items were based on the passage The Ducks Arrive in Spring. In the concrete situation the categories available were color, shape and size. In the reading situation the dichotomous classes were to be constructed from the categories stated in the story, time of arrival, place of arrival, and feeding habits. The predicates that were to be constructed in each case were the expansion of these categories: red and yellow; large and small; round and square; surface feeders and diving ducks; early and late; and ponds and lakes (Rawson, 1969:160).

Figure 25 summarizes the classes, categories and predicates required in each case. In addition, the comparability of the items can also be examined in Figure 25. The categories available in each situation are interchangeable.

Rawson (1969:161) notes that the specific items involved may not necessarily be comparable, however the kinds of decisions required in each case are the same for the concrete and reading situation.

## COMPARABILITY OF CONCRETE AND STORIES TESTS: MULTIPLICATIVE CLASSIFICATION

### Matrix Structure

Test items XIV and XV were used to assess this dimension of classification in the concrete situation. Test items IX(1), X(1) and IX(2), X(2) in Story I, The Ducks Arrive in Spring, and test items II(1), II(2) in Story II, Jim and His Garden, were used to assess this dimension of classification in the reading situation. In this dimension of classification the subject was required to abstract the

| CCO | | | SCO | | |
|---|---|---|---|---|---|
| Item | Class | Category | Item | Class | Category |
| XI. | $\hat{x}$ . . . $R_x$<br>. . . $R_x$ | Color<br>- red<br>- yellow | V. | $\hat{x}$ . . . $T_{1x}$<br>. . . $T_{2x}$ | Time<br>- early<br>- late |
| XII. | $\hat{x}$ . . . $L_x$<br>. . . $S_x$ | Size<br>- large<br>- small | VI. | $\hat{x}$ . . . $P_{1x}$<br>. . . $P_{2x}$ | Place<br>- ponds<br>- lakes |
| XIII. | $\hat{x}$ . . . $Ro_x$<br>. . . $Si_x$ | Shape<br>- round<br>- square | VII. | $\hat{x}$ . . . $H_{1x}$<br>. . . $H_{2x}$ | Habitat<br>- surface feeding<br>- diving ducks |

Figure 25

The Construction of Predicates: CCO XI, XII, XIII and SCO V, VI, VII
(Rawson, 1969:161)

critical properties, multiply these properties to form new classes and position the classes in a matrix structure. However, as Rawson (1969:162) suggests, this may not necessarily be the operational order used by subjects to solve these problems.

Test items IX(1) and X(1) SCO were adopted directly from Rawson (1969:330), and test items IX(2) and X(2) SCO were added to the original format. Test items IX(2) and X(2) SCO were primarily a repetition of the original matrix question. In addition to the question being repeated, the researcher stated all the necessary information to the subject considered essential to solve the problem. This repetition, of all the essential information, was used in an attempt to ensure that the subject had access to all the necessary information required to solve the problem.

Story II and test items II(1) and II(2) were designed by the researcher in an attempt to make the two conditions, concrete and story, more equivalent. (Appendix B)

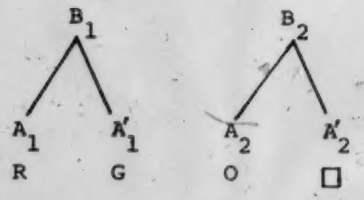
The comparability of the items IX(1), X(1) SCO, Story I, and items XIV and XV CCO may be examined in Figure 26 and the comparability of the concrete items and the items II(1) and II(2) SCO, Story II, may be examined in Figure 27.

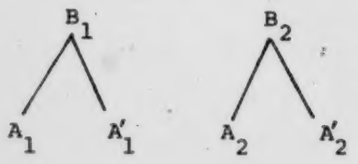
The items in the two areas, concrete and story, involve essentially similar dimensions of classification. However, due to the nature of the reading task, the extent to which the subject placed the multiplicative classes in a matrix structure could not be assessed. This is considered to be an essential difference between the two situations, concrete and story, and is considered to be a limitation

CCO

SCO Story I

Abstraction of Properties
(Simultaneous Classification)





Multiplication of Properties

CCO:

$A_1 \times A_2$ $A'_1 \times A_2$

$A_1 \times A'_2$ $A'_1 \times A'_2$

SCO Story I:

$A_1 \times A_2$ $A'_1 \times A_2$

$A_1 \times A'_x$ $A'_1 \times A'_2$

Matrix

Items

XIV. $A_1A_2$ = R O $A_1A'_2$ = G O
$A'_1A_2$ = R □ $A'_1A'_2$ = G □
(verbal)

XV. Same
(concrete)

Items

IX(1) $A_1A_2$ = pondfeeders $A_1A'_2$ = ⊗
$A'_1A_2$ = ⊗ $A'_1A'_2$ = diving ducks

X(1) Explanation

IX(2) (Repeat if necessary)

X(2)

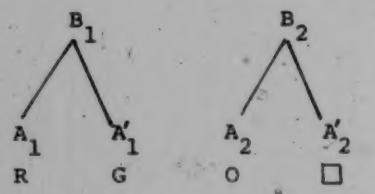
Figure 26

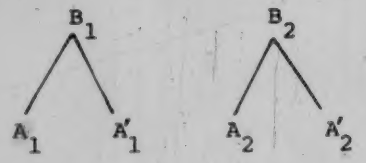
Multiplicative Classes and Relations CCO XIV, XV and SCO IX(1), X(1), IX(2), X(2)
(Rawson, 1969:162)

CCO

Abstraction of Properties
(Simultaneous Classification)

SCO Story II





Multiplication of Properties

CCO:

$A_1 \times A_2$ $\quad A'_1 \times A_2$

$A_1 \times A'_2$ $\quad A'_1 \times A'_2$

SCO Story II:

$A_1 \times A_2$ $\quad A'_1 \times A_2$

$A_1 \times A'_2$ $\quad A'_1 \times A'_2$

Items

XIV. $A_1A_2$ = R O $\quad A'_1A_2$ = G O

$A_1A'_2$ = R □ $\quad A'_1A'_2$ = G □

(verbal)

XV. Same

(concrete)

Matrix

Items

II(1) $A_1A_2$ = little watering sandy soil $\quad A'_1A_2$ = a lot of watering sandy soil

$A_1A'_2$ = little watering loam soil $\quad A'_1A'_2$ = a lot of watering loam soil

II(2) (Repeat if necessary)

Figure 27

Multiplicative Classes and Relations CCO XIV, XV and SCO Story II, II(1), II(2) both in Rawson's study and in the present study. Suggestions as to how this limitation could be partially eliminated will be presented in Chapter VII.

## Intersection

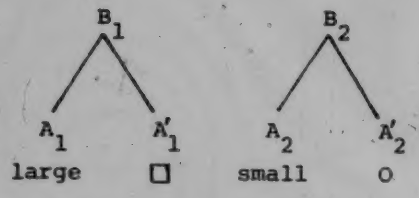
The operations involved in these test items are essentially the same as in matrix structure, except the subject is not required to place the multiplicative classes into a matrix structure. Test items XVI, XVII, XVIII and XIX CCO were used to assess this dimension of classification in the concrete situation. Story III, A City of Long Ago, questions II(1) and II(2) and Story IV, The Twins, questions II(1) and II(2) were used in the reading situation. In this case, Story IV and questions II(1) and II(2) were constructed by the researcher and added to Rawson's (1969:330,334,335) format. Question II(2) consisted of the repetition of the essential data to solve the problem and a restatement of question II(1). It was hoped by the researcher that this procedure would more readily permit the subject to gain access to the information required to solve the problem. (Appendices C and D)

The comparability of the items in the reading and in the concrete situations may be examined in Figure 28. This assessment of Figure 28 suggests that the level of comparability between the concrete and the reading situation in this dimension of classification is satisfactory.

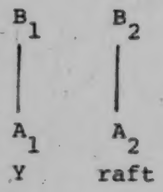
CCO

SCO

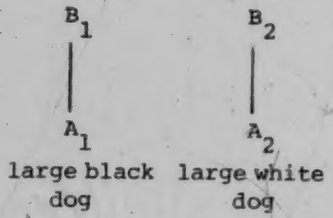
Abstraction of Properties


$B_1$
$A_1$
large
$A'_1$
□
$B_2$
$A_2$
small
$A'_2$
O

Story III


$B_1$
$A_1$
Y
$B_2$
$A_2$
raft

Story IV


$B_1$
$A_1$
large black dog
$B_2$
$A_2$
large white dog

Multiplication of Criterial Properties

Items

XVI. $A_1 \times A'_2$ = Large O (verbal)

XVII. Same (concrete)

XVIII. $A'_1 \times A_2$ = small □ (verbal)

XIX. Same (concrete)

Items

II(1) $A_1 \times A_2$=yellow raft

II(2) (Repeat if necessary)

II(1) $A_1 \times A_2$=large black & white dog

II(2) (Repeat if necessary)

Figure 28

Multiplicative Classes and Relations (Intersection)
CCO XVI, XVII, XVIII and XIX and
SCO Story III, II(1), II(2), and
Story IV, II(1), II(2)
(Rawson, 1969:163)

## ADMINISTRATION PROCEDURE

Each subject was individually assessed, and assigned randomly to the treatment conditions.

Prior to each testing session the subject was presented with a brief overview of the tasks he was expected to do. The subject was also encouraged to ask questions if he had difficulty understanding any of the test instructions. The instructions were given verbally by the researcher as stated in Appendices A, B, C, D, E and F.

The test items were divided into seven major units and randomly administered to each subject. The units were: Story I, Story II, Story III, Story IV, Additive Classification CCO and Multiplicative Classification (Matrix) CCO, and Multiplicative Classification (Intersection). Initially, in each testing session, the subject was presented with the Digit Span Subtest. In an attempt to assess the subjects' rate of reading, all subjects were timed in each of the reading situations.

The specific questions and queries used in each task are given in Appendices A, B, C, D, E and F. In addition the specific presentation of the concrete materials is stated in Appendices E and F.

## CRITERIA FOR SCORING TEST ITEMS

The criteria for scoring the test items were devised principally from the criteria established by Piaget and Inhelder (1964:59-118,167-184) and Rawson (1969:336-338). An attempt was made by the researcher to construct criteria that would provide both a qualitative and quantitative assessment of the subjects' performance. (See Appendices A, B, C, D, E and F.) In turn, subjects were requested to provide an explanation for all responses except responses to literal comprehension questions.

Additive Classification

Construction of classes. In the CCO condition the subject's response had to meet the conditions a-e as stipulated. In addition, the responses for both the covered and uncovered situation had to be correct for full credit (Appendix E). In the SCO condition, the subject's response had to consist of one clear attribute directly confined to the subordinate class and one clear attribute directly confined to the superordinate class (Appendix A).

Class inclusion. In both the CCO condition and the SCO condition both the response and explanation had to be correct for full credit. Both the response and explanation were required to meet the specific criteria as stipulated (Appendices A and E).

Predication. In the CCO condition the attributes of the dichotomous classes had to be clearly stated. Each attribute stated correctly, and identifying a dichotomous class was credited as one point. The responses were categorized into six specific response types (Appendix A).

In the SCO condition the attributes of the dichotomous classes also had to be stated clearly. Again, each attribute stated correctly and identifying a dichotomous class was credited as one point. The responses were categorized into six specific types (Appendix E).

## Multiplicative Classification

Matrix. In both the CCO and SCO condition, the explanations and responses were categorized according to specific types of responses.

The responses for Story I SCO were categorized into 11 types of responses, and for Story II SCO, 15 types of responses were possible. These are defined specifically in Appendices A and B.

In the CCO condition 15 types of responses were possible. These are defined in Appendix E.

The criteria for the assessment of these responses were based on the criteria devised by Piaget and Inhelder (1964:167,171).

A total score of two was possible for Story I, and a total score of four was possible for the correct solution in Story II. In the CCO condition a total score of four was possible. (Appendices A, B and E.)

Intersection. In both the SCO and CCO condition, the responses were categorized into nine specific types (Piaget and Inhelder, 1964:176-184). (Appendices C, D and F.)

The total possible score for the SCO condition was two and for the CCO condition, the total possible score was two. In the CCO condition, the responses to both questions XVI and XVII had to be correct to receive credit. The same was applicable to test items XVIII and XIX.

Table 12 provides a summary of the range of scores for the specific dimensions of classification.

Table 12

Total Scores for Dimensions of Classification

| Dimension of Classification | Range of Scores | |
|---|---|---|
| | CCO | SCO |
| Additive Classification | 0-16 | 0-21 |
| I. Construction of Classes | 0-2 | 0-6 |
| II. Class Inclusion | 0-8 | 0-9 |
| III. Predicates | 0-6 | 0-6 |
| Multiplicative Classification | 0-6 | 0-8 |
| IV. Matrix | 0-4 | 0-6 |
| V. Intersection | 0-2 | 0-2 |

## SUMMARY

The research instrument is comprised of two major conditions, concrete and reading, and two primary aspects, additive and multiplicative classification. The additive aspect of classification is comprised of three major dimensions, class construction, class inclusion and predication, and the multiplicative aspects is comprised of the major dimensions, matrix class structure and intersection. (See Appendix H for a summary of test items adopted and adapted from Rawson (1969) and test items constructed by the researcher.)

In general, as indicated by the symbolic description of the test items, the tests are considered comparable in both the reading and concrete situation. The administration and scoring procedure is only briefly outlined. However, the reader is referred to Appendices A, B, C, D, E and F for a more comprehensive description of these procedures.

# CHAPTER VI

# FINDINGS OF THE STUDY

The purpose of this study was to assess and measure the extent to which sixth grade more proficient and less proficient readers, age 11 years 1 month to 12 years 4 months, could perform the Piagetian operations of classification in both a reading and concrete situation.

This purpose resulted in the generation of four research questions and hypotheses.

## Research Question 1

Will the mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification not be significantly different?

### Hypothesis 1

The mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification will not be significantly different. ($p > .01$)

## Research Question 2

In the additive reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?.

### Hypothesis 2

In the additive reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers. ($p \leqslant .01$)

## Research Question 3

Will the mean performances of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification not be significantly different?

Hypothesis 3

> The mean performance of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification will not be significantly different. ($p > .01$)

Research Question 4

> In the multiplicative reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?

Hypothesis 4

> In the multiplicative reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers. ($p \leqslant .01$)

The findings will be presented in direct relation to these research questions and hypotheses. The findings related to research questions one and two will be presented first, for both the more proficient and less proficient readers in terms of the following three dimensions:

| | | |
|---|---|---|
| I. | Construction of Classes | CCO, SCO |
| II. | Class Inclusion | CCO, SCO |
| III. | Predication | CCO, SCO |

The results of these three dimensions will then be summed and presented as the additive aspect of classification.

The next two dimensions to be presented for both the more proficient and the less proficient readers will be:

| | | |
|---|---|---|
| IV. | Matrix | CCO, SCO |
| V. | Intersection | CCO, SCO |

The results of these two dimensions will also be summed and presented as the multiplicative aspect of classification.

These findings will then be directly related to research questions three and four.

Initially, a descriptive procedure will be used to present the findings related to the research questions one to four. Following this there will be an analysis of the findings and then a discussion of the findings and statements of support.

Findings related to literal comprehension rate of reading and subject's performance on the digit span subtest will follow under the headings for correlations, classification tasks, memory, rate, and intelligence and classification tasks.

## CONSTRUCTION OF CLASSES

Table 13 presents the total number of correct responses for both more proficient and less proficient readers in the reading and concrete situations. As indicated by the results, the more proficient readers as a whole were able to construct more classes than the less proficient readers, in the reading situation. Even though the differences are small, 89 percent for the more proficient readers and 75 percent for the less proficient readers, the results suggest that the less proficient readers experienced more difficulty with this task than the more proficient readers. Relative to their performance in the concrete situation, the more proficient readers' total percentage correct did not appear to have dropped appreciably in the reading situation. However, the drop in total percentage correct, from the concrete to the reading situation for the less proficient

Table 13

Class Construction Responses (CCO and SCO) by Readers

| Readers | CCO<br>Total Number Correct<br>(Total Possible = 40) | SCO<br>Total Number Correct<br>(Total Possible = 120) |
|---|---|---|
| More Proficient (n = 20) | 40 (100%) | 107 (89%) |
| Less Proficient (n = 20) | 39 (98%) | 90 (75%) |

readers, appears to be far more extensive. Both groups appeared to perform almost equally as well in the concrete situation.

### Class Inclusion

The assessment of Table 14 indicates that the more proficient readers performed better than the less proficient readers in both the reading and the concrete situation. Relative to their performance in the CCO situation, both groups performed far less well in the SCO situation. It would appear that both groups found the reading tasks to be appreciably more difficult than the concrete tasks. However, the less proficient readers found both the concrete and reading tasks more difficult. This and the low performance in general on these class inclusion tasks would suggest that these dimensions of classification are not yet operational for the less proficient readers.

### Predication (Construction of Dichotomous Classes)

An attempt was made by the researcher to categorize the 60 responses per reader group into six different categories. These types of categories were generally based on Piaget and Inhelder's (1964:48) characteristics of classification. This procedure was purely exploratory, and it was hoped by the researcher that the specific categorization procedure used would provide a more qualitative analysis of the subjects' responses. Furthermore, it is not suggested that these response categories should be viewed as distinct sub-stages of development in this dimension of classification. However, an analysis of the trend of the responses may lend insight into general subject performance.

Table 14

Class Inclusion (CCO and SCO) by Readers

| Readers | CCO<br>Total Number Correct Responses<br>(Total Possible = 160) | SCO<br>Total Number Correct Responses<br>(Total Possible = 180) |
|---|---|---|
| More Proficient (n = 20) | 145 (91%) | 119 (66%) |
| Less Proficient (n = 20) | 93 (58%) | 70 (39%) |

The responses of the more proficient and less proficient readers for each question were categorized in terms of six different types of responses. These types of responses and how they were scored are specified in Appendix A. As indicated by the results in Table 15 most of the responses for the more proficient and less proficient readers, in the concrete situation, tended to be a Type V response. This finding suggests that both groups may be equally competent in a classification task in which they have to state a principal criterion, or collection, and form two dichotomous classes in a concrete situation. However, the performance of both groups dropped substantially in the reading situation.

In the reading situation Type V responses were more numerous for the more proficient readers than for the less proficient. The range of responses for the two groups also tended to differ. The less proficient readers appeared to provide more Type I responses (a response in which none of the three major collections or criteria are identified) than the more proficient readers. In addition, as indicated by the NR (no response), 27 for the less proficient readers and 6 for the more proficient readers, the less proficient readers also tended to respond less often.

If one can assume that these test items are a measure of subject flexibility in constructing and dichotomizing a group of items, or ideas into more than one collection of dichotomous classes, the total percentage scores of both groups in both the SCO and CCO condition would suggest that the more proficient readers tend to be more flexible than the less proficient readers in both conditions.

## Table 15

Predication Categories of Responses per Test Item (CCO and SCO) by Readers

| | CCO | | | | | | | | | SCO | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Test Item | Types of Responses | | | | | | | Total Score | Test Item | Types of Responses | | | | | | | Total Score |
| | | I | II | III | IV | V | VI | NR | | | I | II | III | IV | V | VI | NR | |
| More Proficient Readers (n = 20) | XI | - | 2 | - | - | 18 | - | - | | V | - | 2 | 3 | 0 | 15 | - | - | |
| | XII | - | - | 1 | - | 18 | - | - | | VI | 1 | 1 | 2 | 2 | 12 | - | 2 | |
| | XIII | - | 6 | 1 | - | 14 | - | - | | VII | 7 | 1 | - | 1 | 6 | 1 | 4 | |
| Total Number of Types of Responses | | - | 8 | 2 | - | 50 | - | - | | | 8 | 4 | 5 | 3 | 33 | 1 | 6 | |
| Total Score of Types of Responses | | - | 0 | 2 | - | 100 | - | - | 102 (85%) | | 0 | 0 | 5 | 0 | 66 | 0 | 0 | 71 (59%) |
| Less Proficient Readers (n = 20) | XI | - | 3 | - | - | 17 | - | - | | V | 4 | - | 4 | - | 8 | - | 4 | |
| | XII | - | 4 | - | - | 16 | - | - | | VI | 4 | 1 | 1 | - | 2 | 1 | 11 | |
| | XIII | - | 6 | - | - | 14 | - | - | | VII | 4 | - | - | 1 | 1 | 2 | 12 | |
| Total Number of Types of Responses | | - | 13 | - | - | 47 | - | - | | | 12 | 1 | 5 | 1 | 11 | 3 | 27 | |
| Total Score of Types of Responses | | - | 0 | - | - | 94 | - | - | 94 (78%) | | 0 | 0 | 5 | 0 | 22 | 0 | 0 | 27 (23%) |
| | | Total Possible Responses: | | | | | | | 60 | | Total Possible Responses: | | | | | | | 60 |
| | | Total Possible Score: | | | | | | | 120 | | Total Possible Score: | | | | | | | 120 |

This is most evident in the SCO situation, 59 percent for the more proficient readers and 26 percent for the less proficient readers.

These findings in the CCO condition are generally consistent with the findings reported by Piaget and Inhelder (1964:209). In their study involving subjects 8 to 9 years of age, they report that 31 percent of the responses consisted of two criteria, and 69 percent of the responses consisted of three criteria. In all 100 percent of the responses consisted of two or three criteria. It should be noted that these findings and the findings of Piaget and Inhelder are not directly comparable since the procedure used in categorizing the responses differed for the two studies. The findings of this study do support the notion that children age 11 years 1 month to 12 years 4 months should be able to rely on different criteria to form dichotomous classes.

Even though similar operations of classification were involved in the reading situation, both groups appeared to experience difficulty in this condition. Furthermore, the less proficient readers' total percentage score was lower than the more proficient readers' total percentage score. This suggests that the condition or context may have affected the performance of both groups and appreciably affected the performance of the less proficient readers. This may further suggest that the less proficient readers may have access to these operations of classification in a concrete situation but may have difficulty applying and relying on these operations in a reading situation.

## Summing of Class Construction, Class Inclusion and Predication

As indicated by the total scores and total percentage scores in Table 16, the less proficient readers as a group tended to perform less well than the more proficient readers as a group on all the dimensions of additive classification. This occurred for both the reading and concrete situation. In addition, both groups tended to perform less well in the reading situation as opposed to the concrete situation. This is evident for all the aspects of classification.

Both groups of readers tended to perform best in the construction of classes, in both a reading and concrete situation. The more proficient readers, as a whole, performed least well in predication in the concrete and reading situation. The less proficient readers, as a whole, performed least well in class inclusion in the concrete situation and predication in the reading situation.

Of major interest here is the consistent drop of total percentage scores from the CCO condition to the SCO condition for both the more proficient and less proficient readers. This drop in total scores appears to be more dramatic for the less proficient readers.

## Mean Performance Additive Classification

Table 17 presents the data related to the mean performance of both groups. As indicated by the mean percentage scores, the more proficient readers tended to perform better than the less proficient readers in both the concrete and reading situation. The readers in both groups in general performed less well in the reading situation

Table 16

Total Score Additive Classification, for Readers, in CCO and SCO

| Dimension of Classification | More Proficient Readers Total Score | More Proficient Readers % Score | Less Proficient Readers Total Score | Less Proficient Readers % Score |
|---|---|---|---|---|
| CCO: | | | | |
| I. Construction of Classes | 40 | 100 | 39 | 98 |
| II. Class Inclusion | 145 | 90 | 93 | 58 |
| III. Predication | 102 | 85 | 94 | 78 |
| Additive Classification | 287 | 90 | 226 | 71 |
| SCO: | | | | |
| I. Construction of Classes | 107 | 89 | 90 | 75 |
| II. Class Inclusion | 119 | 66 | 70 | 39 |
| III. Predication | 71 | 59 | 27 | 23 |
| Additive Classification | 297 | 71 | 187 | 45 |

Table 17

Mean Performance and Mean Percentage Performance
Additive Classification for Readers in
CCO and SCO

| | Mean Score | Mean Percentage Score | Standard Deviation |
|---|---|---|---|
| CCO: | | | |
| More Proficient Readers | 14.40 | .9001 | .087 |
| Less Proficient Readers | 11.30 | .7064 | .154 |
| SCO: | | | |
| More Proficient Readers | 14.85 | .7072 | .166 |
| Less Proficient Readers | 9.35 | .4452 | .146 |

Total Possible Score for CCO = 16.
Total Possible Score for SCO = 21.

as compared to the concrete situation. However, the drop in mean percentage scores for the less proficient readers was somewhat more extensive. The analysis of the mean performances may suggest that the more proficient readers may be more competent in relying on the operations of classification than the less proficient readers in the CCO condition. They may also be more competent than the less proficient readers in relying on these operations of classification in the SCO condition. However, as indicated by the drop in the mean performance for both groups in the SCO condition, the context in which these operations had to be performed may have affected the subjects' performance. Essentially, both groups appeared to experience more difficulty in relying on these operations of classification in the SCO condition.

## MULTIPLICATIVE CLASSIFICATION

### Matrix

Tables 18 and 19 present the number of types of responses and the total scores for both the more proficient and less proficient readers in a concrete and reading situation. The scores of both groups of readers in the CCO condition differ only slightly. Most of the responses, 85 percent for the more proficient and 88 percent for the less proficient readers, were of a Type VIIa. A Type VIIa response consisted of the following: four major multiplicative classes were stated, all the corresponding dichotomous classes of the major collections are stated and the two major corresponding collections are also stated (Appendices A, B and F). The performance of both

Table 18

Matrix Class Structure Types of Responses Per Test Item in CCO by Readers

|  | Test Item | Types of Responses |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Total Number of Pupil Responses | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | I | II | III | IIIa | IIIb | IIIc | IV | IVa | V | Va | Vb | VI | VIa | VII | VIIa |  |  |
| More Proficient Readers (n = 20) | XIV | - | - | - | - | 2 | - | - | - | 1 | - | 1 | - | 1 | - | 15 |  |  |
|  | XV | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 19 |  |  |
| Total No. of Response Types |  | - | - | - | - | 2 | 1 | - | - | 1 | - | 1 | - | 1 | - | 34<br>(85%) | 40 | 67 (84%) |
| Less Proficient Readers (n = 20) | XIV | - | - | - | - | 1 | - | - | - | - | - | - | - | 2 | - | 16 |  |  |
|  | XV | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | 19 |  |  |
| Total No. of Response Types |  | - | - | - | - | 1 | - | - | - | - | 1 | - | - | 3 | - | 35<br>(88%) | 40 | 70 (88%) |

Total Possible Score = 80.

Table 19

Matrix Class Structure Types of Responses Per Test Item in Story I and II by Readers

| | Test Item | Types of Responses | | | | | | | | | | | | | | | Total Number of Pupil Responses | Total Score | Total Possible Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IIIa | IIIb | IIIc | IV | IVa | V | Va | Vb | VI | VIa | VII | VIIa | | | |
| More Proficient Readers | Story I | | | | | | | | | | | | | | | | | | |
| | IX(1) | - | 1 | - | - | - | - | 2 | 2 | 1 | 13 | 1 | NA | NA | NA | NA | | | |
| | IX(2) | 1 | - | - | - | - | - | - | 2 | 1 | 1 | 1 | NA | NA | NA | NA | | | |
| Total No. of Response Types | | 1 | 1 | - | - | - | - | 2 | 4 | 2 | 14 | 2 | - | - | - | - | 26 | 36(90%) | 40 |
| | | | | | | | | | | | 69% | | | | | | | | |
| | Story II | | | | | | | | | | | | | | | | | | |
| | II(1) | - | - | 1 | 3 | 1 | 8 | - | 1 | - | 2 | 2 | - | - | - | 3 | | | |
| | II(2) | 1 | - | 1 | 1 | 1 | 3 | - | 3 | - | 1 | 1 | - | - | - | 3 | | | |
| Total No. of Response Types | | 1 | - | 2 | 4 | 2 | 11 | - | 4 | - | 3 | 3 | - | - | - | 6 | 36 | 37(46%) | 80 |
| | | | | | 52% | | | | | | | | 44% | | | | | | |
| Less Proficient Readers | Story I | | | | | | | | | | | | | | | | | | |
| | IX(1) | - | 3 | - | - | 1 | - | 6 | 5 | 2 | 3 | - | NA | NA | NA | NA | | | |
| | IX(2) | 1 | 2 | 4 | - | 1 | - | 6 | 4 | - | - | - | NA | NA | NA | NA | | | |
| Total No. of Response Types | | 1 | 5 | 4 | - | 2 | - | 12 | 9 | 2 | 3 | - | - | - | - | - | 38 | 22(55%) | 40 |
| | | | | | | | | | | | 13% | | | | | | | | |
| | Story II | | | | | | | | | | | | | | | | | | |
| | II(1) | 1 | 2 | 8 | 1 | 2 | 5 | - | 1 | - | - | - | - | - | - | - | | | |
| | II(2) | 3 | 1 | 1 | - | 4 | 7 | - | 1 | - | 1 | 1 | - | - | - | 1 | | | |
| Total No. of Response Types | | 4 | 3 | 9 | 1 | 6 | 12 | - | 2 | - | 1 | 1 | - | - | - | 1 | 40 | 10(13%) | 80 |
| | | | | | 72% | | | | | | | | 15% | | | | | | |

groups would suggest that the operations of classification are operational and correspond to Piaget and Inhelder's Stage III development in classification (Piaget and Inhelder, 1964:169).

However, as indicated by the results in Table 19, in the reading situation the total scores of the two groups of readers differ substantially. The total scores of the more proficient readers in both Story I and Story II are higher. This may suggest that the more proficient readers are more able to rely on the operations of classification in a reading situation than the less proficient readers. In addition, 69 percent of the responses of the more proficient readers in Story I ranged from a Type V to a Type Vb response. However, only 13 percent of the responses of the less proficient readers were in the same range. In terms of Story II, the types of responses were generally scattered and ranged from Type I to Type VIIa for both groups of readers. Type III, IIIa, IIIb, and IIIc scores tended to account for approximately 72 percent of the less proficient readers' responses. However, only 52 percent of the more proficient readers' responses were in this range. In terms of the more proficient readers, 44 percent of the responses ranged from Type IV to Type VIIb whereas only 15 percent of the less proficient readers' responses were in this range. These results, in general, would suggest that the more proficient readers performed better, both qualitatively and quantitatively than the less proficient readers in this dimension of classification. The results tend to support Piaget and Inhelder's view of matrix classification. Piaget and Inhelder (1964:169) suggest that Type III responses would develop before Type VII responses. The clustering of responses for the less proficient readers in Story II would provide some support for this claim.

## Intersection

As indicated by the total scores in Table 20, the less proficient readers performed slightly better than the more proficient readers on the concrete tasks. In examining the types of responses, both groups of readers appeared to find question XVI the most difficult. Comparing the subjects' performance on items XVII, XVIII and XIX to their performance on item XVI suggests that the subjects may have been initially confused by the nature of the task. This was further evidenced by the large number of random responses to the test item and the high range of success to items XVII, XVIII and XIX. As indicated by the total types of responses, the majority of the responses for both groups of readers tended to be a Type VIII response, 71 percent for the more proficient readers and 66 percent for the less proficient. The remainder of the responses ranged from a Type I to a Type VII for both groups.

Piaget and Inhelder (1964:178) found that 17.5% of the responses of 9 to 10 year olds matched only one collection and 82.5 percent of the responses matched both collections. In this study, 20 percent of the responses of the more proficient readers matched only one collection (Type I-IV), and 80 percent of the responses matched both collections (Type V-VIII). In terms of the less proficient readers, 23 percent of the responses ranged from Type I-IV and 77 percent ranged from Type V-VIII. The findings cited in this study tend to be supported by results reported by Piaget and Inhelder (1964:178).

Table 20

Intersection Types of Responses Per Test Item in CCO Condition

| | Test Item | Types of Responses | | | | | | | | | Total Number of Pupil Responses | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | IIa | III | IV | V | VI | VII | VIII | | |
| More Proficient Readers (n = 20) | XVI | - | 6 | 3 | 2 | 1 | 1 | 0 | 4 | 3 | | |
| | XVII | - | 1 | - | - | - | - | - | 1 | 18 | | |
| | XVIII | - | 1 | 2 | - | - | 1 | - | - | 16 | | |
| | XIX | - | - | - | - | - | - | - | - | 20 | | |
| Total No. of Response Types | | - | 8 | 5 | 2 | 1 | 2 | 0 | 5 | 57(71%) | 80 | 19(48%) |
| | | | | 20% | | | | | 80% | | | |
| Less Proficient Readers (n = 20) | XVI | - | 3 | 2 | - | 4 | 4 | - | 2 | 5 | | |
| | XVII | - | 1 | - | - | 2 | - | - | 2 | 15 | | |
| | XVIII | 2 | 2 | - | - | - | - | - | 1 | 15 | | |
| | XIX | 2 | - | - | - | - | - | - | - | 18 | | |
| Total No. of Response Types | | 4 | 6 | 2 | - | 6 | 4 | - | 5 | 53(66%) | 80 | 20(50%) |
| | | | | 23% | | | | | 77% | | | |

Total Possible Score = 40.

In addition, Piaget and Inhelder (1964:184) found that 50 percent of the responses of subjects aged 9 to 10 were correct (Type VIII). The findings of Piaget and Inhelder are consistent with the findings in this study (48 percent for the more proficient readers and 50 percent for the less proficient readers). However, due to the initial confusion with item XVI, the extent to which the performance of the subjects in this study is comparable to the performance of Piaget and Inhelder's subjects is not known. It appears that the scores of both groups may have been somewhat depressed by this initial confusion. Consequently, it could be conceivable that these subjects may score higher another time.

As indicated by Table 21, in the reading situation the more proficient readers as a group scored much higher, for both Story III and Story IV, than the less proficient readers. For Story III, 57 percent of the more proficient readers' replies consisted of a Type VIII response, however less than one percent of the responses for the less proficient readers consisted of this response type. The majority of the less proficient readers' replies, 55 percent, consisted of a Type II response.

As indicated by the total types of responses for the two groups of readers on Story IV, the majority of the replies tended to consist of Types VII and VIII. However, the response types were reversed for each group. Essentially, for the more proficient readers, 36 percent and 50 percent of the responses consisted of a Type VII and Type VIII response, respectively. This is compared to 61 percent and 18 percent for the less proficient readers.

Table 21

Intersection Types of Responses Per Test Item in Story III and IV by Readers

|  | Test Item | Types of Responses |  |  |  |  |  |  |  |  | Total Number of Pupil Responses | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | I | II | IIa | III | IV | V | VI | VII | VIII |  |  |
| More Proficient Readers (n = 20) | Story III |  |  |  |  |  |  |  |  |  |  |  |
|  | II(1) | 1 | 2 | 3 | - | 2 | 2 | - | - | 10 |  |  |
|  | II(2) | - | - | 1 | - | 1 | 1 | - | - | 7 |  |  |
| Total No. of Response Types |  | 1 | 2 | 4 | - | 3 | 3 | - | - | 17<br>(57%) | 30 | 17 (80%) |
|  |  |  |  | 33% |  |  |  |  | 67% |  |  |  |
|  | Story IV |  |  |  |  |  |  |  |  |  |  |  |
|  | II(1) | - | 1 | - | - | - | - | - | 9 | 10 |  |  |
|  | II(2) | - | 2 | - | - | - | 1 | - | 2 | 5 |  |  |
| Total No. of Response Types |  | - | 3 | - | - | - | 1 | - | 11<br>(36%) | 15<br>(50%) | 30 | 15 (75%) |
|  |  |  |  | 10% |  |  |  |  | 90% |  |  |  |
| Less Proficient Readers (n = 20) | Story III |  |  |  |  |  |  |  |  |  |  |  |
|  | II(1) | 2 | 13 | 2 | - | 2 | 1 | - | - | - |  |  |
|  | II(2) | 3 | 9 | 3 | - | 2 | 2 | - | - | 1 |  |  |
| Total No. of Response Types |  | 5 | 22<br>(55%) | 5 | - | 4 | 3 | - | - | 1<br>(less than 1%) | 40 | 1 (5%) |
|  |  |  |  | 90% |  |  |  |  | 10% |  |  |  |
|  | Story IV |  |  |  |  |  |  |  |  |  |  |  |
|  | II(1) | - | 1 | - | - | - | 1 | - | 12 | 6 |  |  |
|  | II(2) | - | 3 | - | - | 1 | 1 | - | 9 | - |  |  |
| Total No. of Response Types |  | - | 4 | - | - | 1 | 2 | - | 21<br>(61%) | 6<br>(18%) | 34 | 6 (30%) |
|  |  |  |  | 15% |  |  |  |  | 85% |  |  |  |

Total Possible Score = 20.

In both reading situations, 67 percent and 90 percent of the responses of the more proficient readers matched both collections. For the less proficient readers, 10 percent and 85 percent of the responses matched both collections. In general, this developmental trend would be consistent with that predicted by Piaget and Inhelder (1964:169). However, in Story III only 10 percent of the less proficient readers' responses matched both collections. This may suggest that these readers expressed difficulty in applying these operations to the reading task.

### Summing of Matrix Classification and Intersection

As indicated by the total scores and total percentage score in Table 22, the less proficient readers performed slightly better than the more proficient readers in the concrete tasks. Both groups appeared to experience difficulty with the intersection task. This difficulty may have been due to the subjects initially not understanding the nature of the task. However, since the findings were consistent with those reported by Piaget and Inhelder (1964:169), this difficulty may also have been due to these dimensions of classification not as yet being fully operational for these groups of readers. In further comparing the high number of correct responses to test items XVII, XVIII and XIX to the low number of correct responses to test item XVI, it appears evident to the researcher that item XVI may have not been a valid indicator of subject performance in simple multiplication. It seems conceivable then that this dimension of classification was operational in the concrete situation

Table 22

Total Score Multiplicative Classification for the More Proficient and Less Proficient Readers in CCO and SCO

| Dimension of Classification | More Proficient Readers Total Score | More Proficient Readers % Score | Less Proficient Readers Total Score | Less Proficient Readers % Score |
|---|---|---|---|---|
| CCO: | | | | |
| IV. Matrix | 67 | 84 | 70 | 88 |
| V. Intersection | 19 | 48 | 20 | 50 |
| Multiplicative Classification | 86 | 72 | 90 | 75 |
| SCO: | | | | |
| IV: Matrix | 73 | 61 | 32 | 27 |
| V. Intersection | 32 | 80 | 7 | 18 |
| Multiplicative Classification | 105 | 66 | 39 | 24 |

for both groups of readers.

In the reading situation the more proficient readers performed better than the less proficient readers on all dimensions of classification. However, the total percentage score for both groups is less in the reading than in the concrete situation. This drop appears to be most dramatic for the less proficient readers. This suggests that both groups of readers may have experienced difficulty in applying these operations of classification to the reading situation, however the less proficient readers may have experienced appreciably more difficulty than the more proficient readers in applying these operations to the reading task.

### Mean Performance Multiplicative Classification

Table 23 presents the data related to the mean performance of both groups. As indicated by both the mean percentage score and the mean score of the readers in the CCO condition, the less proficient readers, on the average, performed slightly better than the more proficient readers. However, in the SCO situation, the average performance of the less proficient readers was substantially lower than the mean performance of the more proficient readers. This may suggest that the less proficient readers experience more difficulty in relying on the operations of classification in the reading situation.

## ANALYSIS OF VARIANCE

A two factor analysis of variance with repeated measures was used to test hypotheses one and two. The two factors consisted of (A) groups (MPR, LPR) and (B) treatments (CA, RA). It was assumed

Table 23

Mean Performance and Mean Percentage for More and Less Proficient Readers in Multiplicative Classification in CCO and SCO

| | Mean Score | Mean Percentage Score | Standard Deviation |
|---|---|---|---|
| CCO: | | | |
| More Proficient Readers | 4.300 | .7165 | .259 |
| Less Proficient Readers | 4.450 | .7416 | .171 |
| SCO: | | | |
| More Proficient Readers | 5.250 | .6563 | .233 |
| Less Proficient Readers | 1.700 | .2125 | .137 |

Total Possible Score for CCO = 6.
Total Possible Score for SCO = 8.

that the measures in factor B were repeated. The Newman-Keuls method was used for the multiple comparisons of means (Winer, 1971:442,525-539). Table 24 presents a summary of the mean percentages for the two groups under separate conditions.

To test hypotheses three and four the same procedure was adopted. In this analysis of variance the two factors consisted of (a) groups (MPR, LPR) and (B) treatments (CM, RM), and it was assumed that the measures in factor B were repeated. The Newman-Keuls method was also used for the multiple comparisons of means (Winer, 1971:442,525-539).

For comparative purposes a two sample Hotelling's $T^2$ test and Welch's t test were used to compare the mean performances of the two groups (Morrison, 1967:117; Ferguson, 1971:155).

## Assumptions of Analysis of Variance

The analysis of variance makes three major assumptions concerning the nature of the data to be analyzed:

1. The distribution of the dependent variable from which the samples are drawn is normal.

2. The variances in the populations from which the samples are drawn are equal.

3. The effects of the various factors on the variation are additive.

In terms of the first assumption, the samples were fairly small. Ferguson (1971:219) notes that it is usually not possible to rigorously demonstrate the lack of normality in this kind of data.

In an attempt to assess the extent to which the variances of the groups were equal, the F-test was used. Two of the F-tests were

Table 24

Mean Percentage Performance for More and Less Proficient Readers in Additive and Multiplicative Classification, CCO and SCO

| | Additive Classification | | Multiplicative Classification | |
|---|---|---|---|---|
| | Concrete | Reading | Concrete | Reading |
| More Proficient Readers | (A) .9001 | (B) .7072 | (C) .7165 | (D) .6563 |
| Less Proficient Readers | (E) .7064 | (F) .4452 | (G) .7416 | (H) .2125 |

significant. These were A-E and D-H (level of significance $p < .05$). This indicates that these two variances are not homogeneous. The variances for B-F and C-G were considered homogeneous (level of significance $p < .05$). However, as Hays (1963:408) notes, the possible consequences of non-homogeneity of variance will be minimized if the numbers per cell are equal. The cells in this study each consisted of 20 subjects, therefore it was felt by the researcher that this departure from homogeneity may not have led to results which were seriously in error.

In terms of additivity, as Ferguson (1971:219) suggests, there are no grounds to suspect the validity of this model. In general, as Ferguson (1971:220) suggests, most real data only roughly satisfy the assumptions of additivity, homogeneity, and normality. In addition both Winer (1962:305) and Ferguson (1971:219) note that the analysis of variance is quite robust and reasonable departure from these assumptions should not significantly affect the validity of the inferences drawn from the data.

It was felt by the researcher that the data in this study reasonably met the assumptions. In addition, a number of additional precautions were taken:

1. Percentage mean performance was used as opposed to raw score mean performance.

2. The level of significance for the source of variation, treatment, groups and interaction was set at $p < .01$.

3. The Newman-Keuls method was used to compare the means of groups and treatments. A conservative level of significance, $p < .01$,

was used for all comparisons.

4. A two sample Hotelling $T^2$ test and a Welch's t test was used for comparison purposes.

Table 25 and Table 26 present a summary of the analysis of variance for additive and multiplicative classification. Table 27 presents the post hoc comparisons, Newman Keuls method, and Figure 28 presents a graphic representation of the means for factor A (Groups) and factor B (Treatments) for the analysis of variances, additive and multiplicative classification.

## Analysis of Variance: Additive Classification

As indicated by the results in Table 25, the 'A' main effect groups, $F = 39.931$, and 'B' main effect treatments, $F = 63.340$, are all significant ($p < .01$). This suggests that the effect of the treatments in general differ significantly for the two groups. In addition, the results further indicate that the treatments within groups also differ significantly. This indicates that the treatments in themselves are differing across groups.

The analysis of the mean comparisons indicates that with a conservative level of significance, $p < .01$, the groups differ significantly in their mean performance on additive classification concrete (A, E) and additive classification reading (B, F). The mean treatment conditions (A, B) and (E, F) of the more proficient and less proficient readers also differed significantly ($p < .01$). (See Table 27)

Table 25

Summary of Analysis of Variance, More Proficient and Less Proficient Readers Additive Classification

| Source of Variation | SS | DF | MS | F | P |
|---|---|---|---|---|---|
| Between Subjects | 2.026 | 39 | | | |
| 'A' Main Effects | 1.038 | 1 | 1.038 | 39.931 | 0.0000010 |
| Subjects within Groups | 0.988 | 38 | 0.026 | | |
| Within Subjects | 1.673 | 40 | | | |
| 'B' Main Effects | 1.031 | 1 | 1.031 | 63.340 | 0.0000006 |
| 'A*B' Interaction | 0.023 | 1 | 0.023 | 1.432 | 0.2389270 |
| 'B' x Subjects within Groups | 0.619 | 38 | 0.016 | | |

Table 26

Summary of Analysis of Variance, More Proficient and Less Proficient Readers Multiplicative Classification

| Source of Variation | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Between Subjects | 2.740 | 39 | | | |
| 'A' Main Effects | 0.876 | 1 | 0.876 | 17.871 | 0.0001432 |
| Subjects within Groups | 1.863 | 38 | 0.049 | | |
| Within Subjects | 4.359 | 40 | 1.737 | | |
| 'B' Main Effects | 1.737 | 1 | 1.099 | 43.335 | 0.00000006 |
| 'A*B' Interaction | 1.099 | 1 | .040 | 27.425 | 0.00000067 |
| 'B'x Subjects within Groups | 1.523 | 38 | | | |

Table 27

Summary of Comparison of Means, Newman-Keuls Method, for Groups and Treatments Additive Classification, Multiplicative Classification

| Groups (MPR, LPR) | | | | Treatments (Tasks) | | | |
|---|---|---|---|---|---|---|---|
| Additive Classification: | | | | | | | |
| | Means | | | | Means | | |
| (CA) | A-E | .9001-.7064 | $p < .01$ | (MPR) | A-B | .9001-.7072 | $p < .01$ |
| (RA) | B-F | .7072-.4452 | $p < .01$ | (LPR) | E-F | .7064-.4452 | $p < .01$ |
| Multiplicative Classification: | | | | | | | |
| | Means | | | | | | |
| (CM) | C-G | .7165-.7416 | $p > .01$ | (MPR) | C-D | .7165-.6563 | $p > .01$ |
| (RM) | D-H | .6563-.2125 | $p < .01$ | (LPR) | G-H | .7416-.2125 | $p < .01$ |

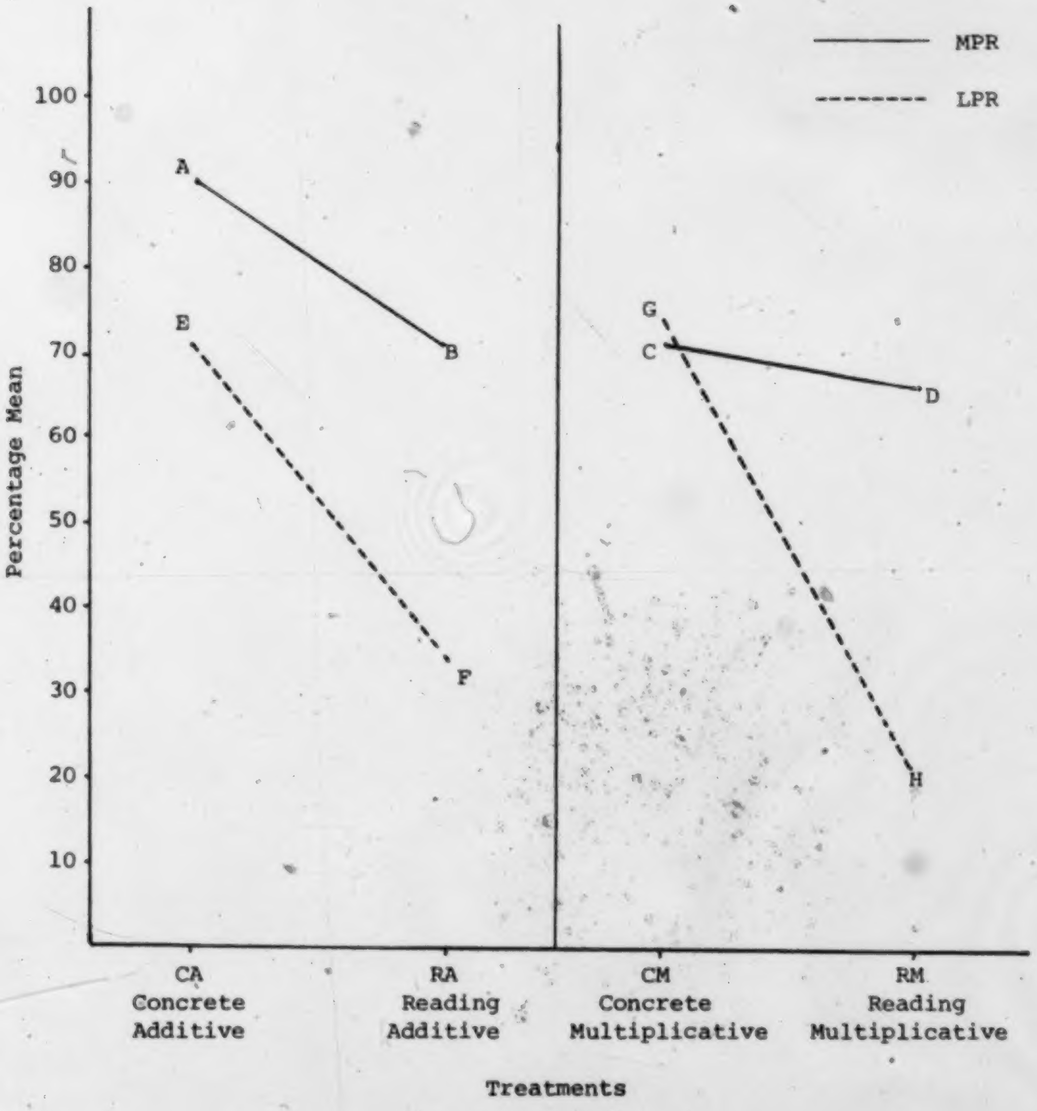


Figure 28

Graphic Representation of Factors A (Groups MPR, LPR) and Factor B (Treatments CA, RA, CM, RM) for Analysis of Variance Additive and Multiplicative

## Analysis of Variance: Multiplicative Classification

The figures in Table 26 indicate the 'A' main effects F = 17.871, 'B' main effects F = 43.335 and 'A' x 'B' interaction F = 27.425 are all significant ($p < .01$). This suggests that the effect of the treatments (tasks in general) differ significantly for the two groups, however the effect of the specific treatments differ for each group. The results further indicate that the treatments within groups also differ significantly.

The analysis of the mean comparisons indicates that with a conservative test of significance, $p < .01$, the groups differ significantly in their mean performance in reading multiplication (D, H). The groups do not differ significantly in their performance on the concrete multiplication tasks (G, C). (See Table 27)

The mean treatment conditions of the more proficient readers (C, D) did not differ significantly, however the mean performances of the less proficient readers, multiplication concrete (G) and multiplication reading (H), did differ significantly.

## Hotelling's $T^2$ Test and Welch's t Test

These procedures were used to check the validity of the results obtained in the initial analysis of variance. The F ratio for the $T^2$ test was 19.0126, $p = .000001$. This indicates that if all the tasks in each group are taken simultaneously, the two groups are significantly different. The Welch's t test for independent samples was used to assess which four means may have contributed to the significant $T^2$.

As indicated by the results in Table 28, all the means were significantly different ($p < .01$) except for the two groups' performance in the concrete multiplication tasks.

The statistical findings here, as compared to the findings in the analysis of variance and the Newman-Keuls mean comparison, are similar. This suggests, that due to the nature of the data, the assumptions of the analysis of variance may not have been extensively violated.

## DISCUSSION OF MAIN FINDINGS

### Research Question 1

> Will the mean performance of the more proficient and the less proficient readers in the additive concrete tasks of classification not be significantly different?

### Hypothesis 1

> The mean performance of the more proficient and the less proficient readers in the additive concrete tasks of classification will not be significantly different.

The results indicate that the two group means did differ significantly at the .01 level of significance (see Table 27 and 28). These statistical findings do not provide support for the hypothesis. However, both groups in general were able to perform the majority of the operations of additive classification. This is generally supported by the findings of Piaget and Inhelder (1964), Ahr and Johnson (1970) and Kofsky (1968). Piaget and Inhelder (1964:103) report 73 percent of the responses of 9 to 10 year old subjects to class inclusion problems were correct. In tasks devised to assess 9 year old children's knowledge of the quantifiers "all" and "some," 81 to 100 percent of the responses were

Table 28

Summary of Mean Comparisons Welch t Test for More Proficient and Less Proficient Readers

| | Means | | | | |
|---|---|---|---|---|---|
| | MPR | LPR | t-Ratio | Prob (2 tail) | Prob (1 tail) |
| CA | .9001 (A) | .7064 (E) | 4.7617 | .00004* | <.01 |
| RA | .7072 (B) | .4452 (F) | 5.1640 | .00001* | <.01 |
| CM | .7165 (C) | .7416 (G) | -0.3533 | .72606 | >.01 |
| RM | .6563 (D) | .2125 (H) | 7.1396 | .0 * | <.01 |

*Level of significance less than .01.

considered acceptable.

In tasks directly related to flexibility (predication) and class construction, administered to subjects ages 8 to 9, Piaget and Inhelder (1964:209) report that 31 percent of the total responses involved two criteria, and 69 percent of the total responses involved three criteria.

In regards to the research findings of this study, 91 percent of the class inclusion responses for the more proficient readers were correct and 58 percent of the responses of the less proficient readers were considered correct. In addition, 85 percent of the responses of the more proficient readers involved the use of three criteria and 78 percent of the responses of the less proficient readers involved the use of three criteria in predication.

The results of this study, as compared to the findings cited by Piaget and Inhelder (1964:63,103,209) are generally consistent, however the performance of the less proficient readers in the class inclusion tasks is noticeably lower. This lower performance may be due to these students not as yet having totally developed the operations of class inclusion. Kofsky's (1968:218) and Ahr and Youniss' (1970:141) findings also tend to support the findings stated here. Kofsky's findings suggest that the operations of class inclusion may not be fully developed until age 11. It seems conceivable then, that the group of less proficient readers, aged 11 years 1 month to 12 years 4 months may not as yet have fully operationalized these operations of class inclusion. The high percentage score of the more proficient readers on the class inclusion tasks suggests that this group of readers may have access to these operations. These results then could suggest that reasonable access to the operations of class inclusion may not be strictly a function of age, but may be more a function of development in general. Essentially, fluctuation in individual access to these operations, in terms of a more general age range, may have to be assumed. This is partially supported by Ahr and Youniss (1970:134). They found that correct responses for older subjects, aged 10 to 10.5, on class inclusion tasks tended to range from 50 to 70 percent.

As indicated by the previous results, both the more proficient and less proficient readers were able to perform the majority of the concrete additive classification tasks, however the more proficient readers performed significantly better than the less proficient readers. This may suggest that both groups do not have equal access to these operations of classification, in the concrete situation. The dimension of classification that appears to primarily account for this significant difference was class inclusion. This would suggest that the operations of additive classification are not as operational for the less proficient readers as they are for the more proficient readers. It seems conceivable that these less proficient readers may experience difficulty in relying on and applying these operations in the reading situation.

Essentially, in terms of reading comprehension, the less proficient readers may experience difficulty in identifying hierarchical classes and relations in the written discourse. They may also experience difficulty in relating first order concepts to second and third order concepts in a hierarchically ordered system. This difficulty with additive classification may also contribute to difficulty in finding the main idea of a paragraph or passage and identifying the relationships of the supporting ideas to the principal or superordinate idea. Essentially, as Rawson (1965:62) suggests, the reader may rely on an ascending technique and sort the subordinate ideas or details into little collections and fail to produce an integrated whole. He may be inflexible and fail to shift his criteria to include all the data and ideas and thus block out some of the more relevant information.

The less proficient reader may also experience difficulty in detecting the overall organization of the discourse. He may not be able to recognize and rely on the subordinate and superordinate organization of some passages to aid in reconstruction of meaning (Kachuck and Marcus, 1976:157).

As Rawson (1965:61) suggests, certain heuristic structures are involved in the development of class relations and higher order concepts or classes. These heuristic structures primarily consist of a "what have we here" kind of attitude, or the establishment of a frame of reference, or universe of discourse. Principally, the child must initially scan the objects to be classified and then form a number of conclusions as to which criterion would be most inclusive. Here the individual must be flexible and be willing to change the criteria for classification if the attempts do not appear to result in mutually exclusive classes. If readers have not developed these heuristic structures in a concrete situation, they may experience difficulty relying on these structures in a reading situation. It seems conceivable that these less proficient readers may have developed these heuristic structures for concrete items but may not have developed them for written discourse.

## Research Question 2

> In the additive reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?

### Hypothesis 2

> In the additive reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers.

As indicated by the findings in Table 27 and Table 28, the mean performance of the more proficient readers was significantly higher than the mean performance of the less proficient readers in the reading tasks of classification (level of significance, $p < .01$). These statistical findings support the hypothesis.

In general, on all dimensions of additive classification, the less proficient readers performed noticeably less well than the more proficient readers. Most noticeable was their poor performance in class inclusion and predication. For the more proficient readers, the total percentage of correct responses for class inclusion was 66 percent and 59 percent for predication. The less proficient readers scored 39 percent and 23 percent respectively.

As indicated by Table 27, the means of both groups (A, B) and (E, F) are significantly different at the .01 level of significance ($p < .01$). This suggests that both groups, in general, performed less well in the reading situation than in the concrete situation. This may be due to these groups of readers having significant difficulty in applying and relying on the operations of additive classification in the reading situation. However, it is also conceivable that the performance of these readers is affected by the novelty of the reading material.

Both groups experienced difficulty in explicitly relying on these operations in the reading situation, however the less proficient readers appeared to experience significantly more difficulty in the reading situation than the more proficient readers.

The less proficient readers in attempting to comprehend what they read appeared to experience difficulty in identifying classes and relations. They also experienced difficulty in organizing and reconstructing novel classes and relations. Principally, due to these readers experiencing difficulty gaining access to and applying these operations of classification to a reading task, and in comprehending what they read, they may also have experienced difficulty in relating first order concepts to second and third order concepts. These readers could also have experienced difficulty in detecting the main idea and the subordinate and superordinate relationship of the ideas in the passage. Furthermore, if these readers experienced difficulty in detecting this relationship of ideas and concepts, they may also experience difficulty in recalling and remembering these units of information. The performance of the less proficient readers suggests that they may not have developed the heuristic structures required to detect the theme and the universe of discourse. This could have affected their performance in detecting and forming dichotomous classes (predication).

As indicated by the performance of the readers in the concrete situation, both groups had access to the operations of classification. However, the extent to which the subjects may have been able to consistently rely on these operations to complete the additive classification tasks differed significantly. It would appear that both groups experience difficulty in further relying on these operations of additive classification in the reading situation. As indicated by the mean comparisons within treatments (Table 27) (A-B, E-F), the mean performance of the more proficient and less proficient readers is significantly lower in the additive reading tasks, as compared to the additive concrete tasks. However, it is conceivable that the lower mean performance of these two groups in the reading situation may be due to the inequivalence of the concrete and reading conditions. As discussed in Chapter IV, the conditions may involve and measure similar operations of classification, however the content of the two conditions is different; principally, counters in the concrete situation and birds and ducks in the reading situation. The subjects may have been more familiar with the concrete content than the content in the reading situation.

It is also possible that both groups of readers when dealing with concrete items may be able to rely on their heuristic structures, and operations of additive classification. However, when attempting to comprehend reading material, these groups experience difficulty relying on these operations and dimensions of classification in detecting the main idea, and the subordinate and superordinate structure of the reading material. These readers may also experience difficulty in relying on these operations to detect the hierarchical relationship of the concepts implicitly involved in attempting to comprehend what they read.

## Research Question 3

> Will the mean performances of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification not be significantly different?

### Hypothesis 3

> The mean performance of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification will not be significantly different.

As indicated by the data (Table 27 and 28), the means of the two groups were not significantly different at the .01 level of significance ($p < .01$). These statistical findings support the research hypothesis and are generally consistent with the findings of Piaget and Inhelder (1964), Shantz (1968) and Findlay (1971). Piaget and Inhelder (1964:158) found that at age 9, 90 percent success could be expected with matrix classification, and 50 percent success could be expected for intersection. This is, in general, consistent with the results in this study, 85 percent for the more proficient readers and 88 percent for the less proficient readers in matrix class structure. In the dimension of intersection the percentage correct was 48 percent for the more proficient readers and 50 percent for the less proficient readers. Findlay (1971:98) found that subjects aged 8 and 10 performed better on matrix multiplications than on simple multiplication. Shantz (1968:250) found that with regards to age, multiplicative ability tended to improve significantly with age. This was evidenced by the older subjects performing better on multiplicative classification tasks.

These operations and dimensions of classification are both directly and indirectly involved in reading comprehension. The direct involvement of these operations is exemplified by the reading situation in which the child must create a matrix or intersect class structure to answer a specific comprehension question, or solve a problem through use of these structures. This may be the case for the stories and questions used in this study.

The less direct or indirect involvement of these operations may be involved in the reader detecting and utilizing a matrix class structure to organize the information he has read, and the understanding of the conjunction and disjunctive relationships expressed by the connectives "and" and "or." In addition, the reader may also have to rely on certain heuristic structures. He may have to rely on hindsight and foresight and be flexible in the multiplicative classes he forms and the extent to which he organizes these structures in a matrix class structure. In the organization of the discourse in a matrix, the author may provide the reader with specific cues related to how the information should be organized, however the reader has to provide the essential logical operations to systematically organize and comprehend the information (Rawson, 1965: 87).

In terms of the concepts of conjunction and disjunction, the reader may have to be able to recognize the three subclasses and the interrelationship of these subclasses in the basic intersection model.

Essentially, the overlapping class may be related in terms of conjunction or disjunction.

As indicated by the performance of both groups of readers in the concrete situation, the readers appear to have reasonable access to these operations and dimensions of classification in the concrete situation. It seems conceivable then, that if both groups have access to these operations of classification in one kind of concrete situation, these groups should also be able to gain access to these operations in the reading situation. However, as suggested by Jenkinson (1976:62) and Walker (1976:146), the reading task may be more abstract. This is due to the following factors: (1) meaning must be reconstructed by directly analyzing the written language, (2) reading material is more ideational, (3) the written language is comprised of more deeply embedded ideas and a greater density of concepts, (4) the ideas presented tend to be organized and contained in larger units of thought, and (5) the general ideas are presented in a more logical structured manner (Jenkinson, 1976:61-64; Walker, 1976:146). These factors contributing to the more abstract nature of the reading task may affect the performance of the less proficient readers.

### Research Question 4

> In the multiplicative reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?

### Hypothesis 4

> In the multiplicative reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers.

As indicated by the results in Table 27 and Table 28, the mean performance of the more proficient readers is significantly greater than the mean performance of the less proficient readers ($p < .01$). These findings would support the research hypothesis. The less proficient readers performed less well than the more proficient readers on all dimensions of multiplicative classification in the reading situation. The total percentage of correct responses for the more proficient readers in matrix class structure and intersection was 61 and 80 percent respectively. The less proficient readers' total percentage score was 27 percent in matrix class structure and 18 percent in intersection.

Again, as in the dimensions of additive classification, concrete and reading, there is a drop in the total percentage score from the concrete to the reading condition for both groups of readers. However, the difference for the less proficient readers appears to be far more dramatic. This is evidenced by the significant differences between means G-H for the less proficient readers. The means C-D of the more proficient readers were not significantly different, at the .01 level (see Table 27). This evidence suggests that the more proficient readers may be more able to rely on the operations of multiplicative classification in the reading situation than the less proficient readers. However, it is also conceivable that the difference in performance of the two groups may be largely a function of subjects' familiarity with the content used in the reading and concrete situation. Essentially, the less proficient readers may have been less familiar with the content of the reading material and thus the situation may have been more abstract for them.

The findings do suggest that the more proficient readers experience much less difficulty in relying on these multiplicative operations of classification to comprehend the written material and answer the specific comprehension questions than the less proficient readers. The extent to which the more implicit use of these dimensions of classification, in matrix structure of prose, heuristics of multiplicative classification, and conjunctive and disjunctive connectives may have affected the less proficient readers' performance, is not known. It does seem conceivable that if a group of readers experience difficulty with multiplicative classification in a concrete situation (a situation involving the more explicit use of these operations), these readers may also experience difficulty in a reading situation (involving the more implicit use of these operations). Essentially, in attempting to reconstruct the meaning and comprehend what they read, the less proficient readers may experience difficulty in identifying the matrix structure of the prose, relying on the heuristics of multiplicative classification and understanding the significance of the conjunctive and disjunctive connectives.

## Additional Observation

With the exception of the dimensions of matrix classification and intersection, for the more proficient readers, the subjects, in general, performed significantly less well in all reading situations as compared to the concrete situations. ($p < .01$) (See Table 27, p. 187). This may suggest that the reading tasks may have involved more formal conditions and may be a more abstract task for both groups of readers.

Essentially, reading material tends to be more ideational and the meaning must be reconstructed by directly analyzing the written language. In written discourse the ideas presented tend to be organized and contained in larger units of thought, and are presented in a more logical structured manner. The written language is also comprised of more deeply embedded ideas and a greater density of concepts (Jenkinson, 1976:61-64; Walker, 1976:141). These factors contribute to the more abstract nature of the reading task, and may be reflected in the lower reading comprehension scores, in SCO, RA, RM, by both groups of readers.

## CORRELATIONS FOR CLASSIFICATION TASKS

The Pearson product-moment correlation coefficient was calculated for the four treatments. These are additive classification concrete (CA), additive classification reading (RA), multiplicative classification concrete (CM) and multiplicative classification reading (RM). In addition, the CA and CM scores and RA and RM scores were combined, and a correlation coefficient was calculated. All these correlations were calculated for both the more proficient and less proficient readers.

### Results

As indicated by the results presented in Table 29, all the correlations, except (B-D) (RA), (RM) for the more proficient readers are not significant at the .05 level of significance. This, in general, may suggest that the tasks or treatments are independent of each other.

The correlations of the concrete condition versus reading condition for the more proficient and less proficient readers were .201 and .293 respectively. These correlations are both not significant at the

Table 29

Summary of Correlations for More and Less Proficient Readers in the Four Treatment Conditions

| Treatments | More Proficient Readers | Less Proficient Readers |
|---|---|---|
| CA-RA | .219 (A-B) | .269 (E-F) |
| CA-CM | .222 (A-C) | .381 (E-G) |
| CA-RM | -.115 (A-D) | .217 (E-H) |
| RA-CM | .203 (B-C) | -.002 (F-G) |
| RA-RM | .506* (B-D) | -.176 (F-H) |
| CM-RM | .112 (C-D) | .075 (G-H) |
| (CA,CM),(RA,RM) | .201 (A-B),(C-D) | .293 (E-F),(G-H) |

* $p < .05 < .444$

at the .05 level of significance. These findings are consistent with Rawson's (1969:241) reported correlation of .13 for the same conditions. The correlation of .13 was also not significant at the .05 level of significance.

The only significant correlation was between reading addition and reading multiplication for the more proficient readers. This correlation of .506 was significant at the .05 level of significance. This finding was consistent with the findings reported by Kretschmer (1972:52). He reported a correlation of .50 between additive and multiplicative classification for a group of grade six readers. However, since the reading material and the subjects used in this study differ from Kretschmer's study, the comparability of the results may be suspect.

As indicated by the previous discussion of the means (see Table 27), all the readers tended to perform less well in the reading tasks than in the concrete tasks. This is partially reflected in these correlations. What was suggested previously was that this may be due to the readers not having equal access to the operations of classification in both a concrete and reading situation. What may account for this is subject to speculation. Familiarity with the content could be a factor here. As Piaget and Inhelder (1964:110) suggest, the emergence of concrete operational reasoning depends very closely on the intuitive character of its content. This suggests that different results on classification tasks can result if the classes to be constructed are more remote from everyday experiences. Furthermore, these classes would also be more abstract (Piaget and

Inhelder, 1964:110). Since the correlations between all the concrete and reading situations for both groups are not significant, this may have been the case in this study. Essentially, the reading comprehension task was of a more abstract nature and consequently the subjects tended to perform less well. What may also be suggested here is that readers on the verge of formal operations, even if they have access to these dimensions and operations of classification in a concrete situation, may have to be taught to apply and rely on these operations when attempting to comprehend and reconstruct the meaning of what they read.

However, the correlations reported in this study may be suspect, and are subject to the following limitations:

1. The groups in themselves are highly homogeneous with respect to the variables reading comprehension (LC and CC), verbal and nonverbal intelligence, vocabulary, rate of reading, and scores obtained in the classification tasks. This results in a restriction of range, with the consequence of lower than expected correlations between these variables. This possibly accounts for the low correlations obtained in this study (Edwards, 1976:70).

2. Edwards (1976:54) notes that the magnitude of a correlation is influenced by the shape or distribution of the X and Y values. The distributions of the values of the variables used in this study were not known and possibly this could account for the low correlations.

3. Correlations based on small samples may be quite misleading. For instance, if the population correlation coefficient is equal to zero, and if random samples of n = 20 observations are

drawn from the population, it is expected that in 95 out of 100 samples the correlation coefficient will fall within the range -.43 to +.43 (Ferguson, 1971:457; Edwards, 1976:56). In addition, with small samples a single pair of (X, Y) values may contribute quite excessively to the value of the correlation coefficient.

4. In a number of cases there appeared to be a ceiling effect. For instance, in the CA and RA condition, 40 percent and 15 percent respectively of the more proficient readers achieved a score of 90 percent or more. This effect has a tendency to reduce the correlation coefficient.

## MEMORY

### Literal Comprehension

The Welch's t test was used to assess whether the mean performance of the two groups in literal comprehension was significantly different (Ferguson, 1971:155).

Table 30

Mean Scores of Readers in Literal Comprehension Subtest, Bond Balow Hoyt, and Stories

| | Literal Comprehension | |
|---|---|---|
| | Bond Balow Hoyt | Stories I, II, III, IV |
| More Proficient Readers | 43.30 | 23.45 |
| Less Proficient Readers | 29.10 | 17.65 |

The means of both groups were significantly different at the .01 level (Bond Balow Hoyt, t = 10.014, p = 0.0 and the Stories I, II, III and IV, t = 4.54, p = 0.00007).

The results presented here would suggest that the more proficient readers, as a group, were able to recall more of the specific details and ideas in both of the literal comprehension tests than the less proficient readers. This only refers to the first attempt in answering the literal comprehension question.

## Digit Span

The mean performance of the two groups on the WISC(R) digit span subtest was 9.70 for the more proficient readers and 8.20 for the less proficient readers. All the raw scores were adjusted to scale scores according to the test norms. The result of the Welch's t test for independent samples, t = 1.80, p > .05, indicates that the two means did not differ significantly at the .05 level of significance. This suggests that the slight differences found between the two means may be largely due to chance, and the performance of both groups was relatively similar.

Of interest here is the large and significant difference between the two groups in the literal comprehension tests and the minimal difference between the two groups in the digit span subtests. It would appear that if subjects were required to immediately recall less meaningful information their performance differed very little. However, in the recall of more meaningful information, which had to be reconstructed from text, the groups differed significantly. This suggests that the more proficient readers were more able to recall meaningful information. What can account for this difference is largely speculative. For instance, the different content involved could have affected the subjects' performance. The fact that in one situation the information had to be read, while in the other it was presented orally by the researcher could have also affected performance.

## RATE

A two factor analysis of variance (groups) with repeated measures on factor B (rates) was used to assess whether there were significant differences across groups and across treatments (Winer, 1971:520). Both the A main effect groups (F = 16.421, p = .0002) and B main effect rates (F = 6.151, p = .0007) were significant at the .01 level. The A x B interaction (F = 1.479, p = .2240) was not significant. These results suggest that the groups and treatments as a whole are significantly different. The Newman-Keuls procedure was used to compare the means (Table 31) (Winer, 1971:528).

Table 31

Summary of Means for Rate, Story I, II, III, IV, More Proficient and Less Proficient Readers

| | Story I (Ducks) | Story II (Garden) | Story III (Corner) | Story IV (Twins) |
|---|---|---|---|---|
| More Proficient Readers | 199 | 235 | 243 | 226 |
| Less Proficient Readers | 168 | 181 | 182 | 184 |

The rate for Story I (Ducks) differed significantly from all the other rates II (Garden), III (Corner), and IV (Twins) at the .01 level of significance. The other rates did not differ significantly from one another. In across group comparisons, more proficient versus less proficient readers, rates for stories II (Garden) and III (Corner) differ significantly (level of significance .01). The differences for story I (Ducks) and story IV (Twins) were not considered significant.

The findings would suggest that the more proficient readers, in general, read the stories faster than the less proficient readers.

To assess the probable extent of the relationship between rate and reading comprehension, a correlation coefficient was calculated for the following: literal comprehension stories, Literal Comprehension (Bond, Balow and Hoyt) and Creative Comprehension (Bond, Balow and Hoyt) and the rates for stories I, II, III and IV. The analysis of the results indicated that the correlations were not significant at the .05 level. It should be noted that the correlations calculated are subject to the same limitations as discussed previously.

The extent to which reading comprehension and rate of reading are associated is still inconclusive (Witty, 1969:103; Farr, 1969:45). In addition, the extent to which faster reading results in better comprehension is not substantiated by research evidence. As Farr suggests, many students who are slow readers are also good comprehenders and also many slow readers are poor comprehenders. Noticeably, both good and poor comprehenders can also be fast readers (Farr, 1969: 46).

## INTELLIGENCE AND CLASSIFICATION TASKS

As indicated by Table 32, the correlation between reading multiplication and nonverbal IQ for the more proficient readers was

Table 32

Correlations between Verbal and Nonverbal Intelligence and Classification Tasks for Readers

| Tasks | | More Proficient Readers | Less Proficient Readers |
|---|---|---|---|
| Concrete Addition | Verbal IQ | .044 | .033 |
| Reading Addition | Verbal IQ | .331 | .301 |
| Concrete Multiplication | Verbal IQ | .405 | .183 |
| Reading Multiplication | Verbal IQ | .402 | -.121 |
| Concrete Addition | Nonverbal IQ | .217 | .200 |
| Reading Addition | Nonverbal IQ | .346 | .299 |
| Concrete Multiplication | Nonverbal IQ | .206 | .088 |
| Reading Multiplication | Nonverbal IQ | .488* | .008 |

n = 20

* $p < .05$

significant at the .05 level. All the other correlations between the tasks of classification and verbal and nonverbal intelligence for the more proficient and less proficient readers were not significant. These findings for the more proficient readers are generally consistent with the correlations between the additive and multiplicative reading classification tasks and Lorge Thorndike intelligence reported by Kretschmer. Kretschmer (1972:52) reported a significant correlation of .54 for additive classification and intelligence and .52 for multiplicative classification and intelligence for grade six readers. In this study, the correlations for the less proficient readers are much lower. The low correlations, in general, for both groups may suggest that the Lorge Thorndike Intelligence Test and the classification tasks may involve different kinds of logical operations. These correlations should, however, be interpreted with caution. This is primarily due to the limitations of highly homogeneous groups, distribution shape, sample size and the ceiling effects.

## SUMMARY

With the exception of the concrete multiplication tasks the more proficient readers tended to perform better than the less proficient readers on all the classification tasks. The findings support hypotheses two, three and four. Hypothesis one was not supported by the findings. The findings generally suggest that the more proficient readers were more able than the less proficient readers to rely on and apply the operations of classification when attempting to comprehend what they read. Except for the correlation between RA and RM and the correlations between the condition RM and nonverbal intelligence, all the other correlations were not significant. However, due to the limitations restriction of range, shape of the distribution, small samples, and ceiling effect, all the correlations in this study should be interpreted with caution. In addition, significant mean differences between the two groups of readers were found in rate of reading and literal comprehension.

# CHAPTER VII

# SUMMARY, CONCLUSIONS AND IMPLICATIONS

This chapter will present a brief summary of the study, the main findings and conclusions. In addition, further limitations, implications of the study for the teaching of reading comprehension and suggestions for further research will also be discussed.

## SUMMARY OF THE STUDY

This study was designed to investigate the extent to which more proficient and less proficient readers could perform the operations of classification in both a concrete and reading situation. A sample of 20 more proficient and 20 less proficient readers were selected from an initial population of 219 grade six subjects.

The New Developmental Reading Test: Intermediate Level, Bond, Balow and Hoyt (1968) was used to obtain a Vocabulary, Literal Comprehension, and Creative Comprehension score for all 219 subjects. In addition, verbal and nonverbal IQ scores based on the Canadian Lorge-Thorndike Intelligence Tests, Level D, Form I, were obtained for all the subjects.

The 20 more proficient readers achieved a raw score of 38 or more on the Creative Comprehension subtests, and obtained a Literal Comprehension and vocabulary subtest score above the 50th percentile rank.

The 20 less proficient readers obtained a raw score of 25 or less on the Creative Comprehension subtests and a Literal Comprehension and vocabulary subtest score above the 50th percentile rank. For both groups the percentile rank was based on test norms.

Each subject was presented with a series of classification tasks in both a concrete and reading situation. For a summary of the questions adopted and adapted from Rawson's (1969) original instrument, and questions developed by the researcher see Appendix H. Five dimensions (class construction, class inclusion, predication, matrix classification and intersection) and two major aspects of classification (additive and multiplicative classification) were assessed in both situations.

A descriptive procedure was used to analyze the subjects' responses. This procedure was primarily exploratory in nature and was based on the criteria established by Piaget and Inhelder (1964: 48,167-184).

The data were analyzed using both a two way analysis of variance with repeated measures for the conditions additive classification concrete and reading, and multiplicative classification concrete and reading. A Newman-Keul's procedure was used for the multiple comparison of means. In addition, the Hotellings $T^2$ test, Welch's t test, and Pearson product-moment correlation coefficients were used to analyzed the results.

## MAIN FINDINGS AND CONCLUSIONS

Four research questions and hypotheses were posed and an analysis of the data was made in an attempt to answer these questions and hypotheses.

Research Question 1

> Will the mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification not be significantly different?

> Hypothesis 1
>
> > The mean performances of the more proficient and the less proficient readers in the additive concrete tasks of classification will not be significantly different.
> >
> > (Level of significance: p greater than .01)

The mean performances for the two groups were significantly different ($p < .01$). These findings did not support the research hypothesis.

The two groups were able to perform the majority of the concrete tasks, however the more proficient readers performed significantly better than the less proficient readers. This suggests that the two groups of readers may not have equal access to all these operations of classification, in a concrete task situation. The dimension of classification that appeared to primarily account for this significant difference was class inclusion. This would suggest that the operations of additive classification are not as operational for the less proficient readers than the more proficient readers. The two groups did not appear to differ appreciably in terms of class construction and predication.

It seems conceivable that since these two groups did not appear to have equal access to these operations or dimensions of classification in a concrete situation, the two groups should differ substantially in the extent to which they can rely on these operations in the reading situation. Essentially, the less proficient readers may experience more difficulty in completing reading comprehension tasks that require the construction of hierarchical class relations and the construction of class inclusion relations. Furthermore, these readers may also experience difficulty in applying and relying on these dimensions of classification in detecting and identifying the subordinate and superordinate relationship of concepts, the main idea, and universe of discourse.

### Research Question 2

> In the additive reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?

#### Hypothesis 2

> In the additive reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers.
>
> (Level of significance: p less than .01)

The mean performance of the more proficient readers was significantly higher than the mean performance of the less proficient readers ($p < .01$). These findings lend support to the research hypothesis.

In this situation, the less proficient readers tended to perform less well than the more proficient readers in all dimensions of classification. As was partially predicted by their performance on the concrete tasks, these readers experienced difficulty in detecting and identifying hierarchical and class inclusion relations in what they read. They also experienced difficulty in constructing and reorganizing classes. It would appear that since the dimensions of additive classification are implicitly involved in relating first, second and third order concepts, identifying the main idea and identifying the subordinate and superordinate relationships of ideas in a reading passage, the less proficient reader will experience difficulty with these aspects of reading comprehension.

Research Question 3

> Will the mean performances of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification not be significantly different?

Null Hypothesis 3

> The mean performances of the more proficient and the less proficient readers in the multiplicative concrete tasks of classification will not be significantly different.
>
> (Level of significance: p greater than .01)

The mean performances of these two groups were not significantly different ($p > .01$). These findings support the research hypothesis.

In this aspect of classification, both groups of readers appeared to perform equally as well on the dimensions matrix class structure and intersection. In addition, the performance of both groups was considered adequate. This suggests that both groups of readers have equal access to these operations of classification in a concrete situation. In reading comprehension these dimensions of classification are intrinsically involved in solving problems and reaching decisions that may require the use of these operations. This may involve the reconstruction of novel classes and class structures. These operations or dimensions may also be intrinsically involved in detecting and organizing information that may be presented by the author in a matrix form, and the disjunctive and conjunctive relationships expressed by the connectives "or" and "and." It seems conceivable to the researcher that if the reader has not mastered these operations in a concrete situation he will not be able to rely on these dimensions of classification when attempting to reconstruct the meaning of what he reads.

### Research Question 4

> In the multiplicative reading tasks of classification will the mean performance of the more proficient readers be significantly higher than the mean performance of the less proficient readers?

#### Hypothesis 4

> In the multiplicative reading tasks of classification the mean performance of the more proficient readers will be significantly higher than the mean performance of the less proficient readers.
>
> (Level of significance: p less than .01)

The mean performance of the more proficient readers was significantly higher than the mean performance of the less proficient readers ($p < .01$). These findings support the research hypothesis.

On this aspect of classification the less proficient readers performed less well than the more proficient readers on both matrix class structure and intersection. This suggests that the less proficient readers experienced difficulty in relying on and applying these dimensions of classification in attempting to reconstruct and comprehend the meaning of what they read. More specifically, they experienced difficulty in constructing novel multiplicative classes. In addition, they experienced difficulty in constructing multiplicative classes and relating these classes to a matrix class structure.

In reading comprehension these dimensions and operations of multiplicative class structure are intrinsically related to the reader detecting and relying on the matrix structure of prose, the heuristics of multiplicative classification and the understanding of conjunctive and disjunctive connectives. It seems probable then that these less proficient readers may also experience difficulty with these aspects of reading comprehension.

## GENERAL CONCLUSIONS

On the basis of the findings reported in this study, the following general conclusions are made.

1. The more proficient readers, in attempting to reconstruct the meaning of what they read, performed significantly better on reading tasks involving the operations and dimensions of classification than the less proficient readers.

2. The more proficient and the less proficient readers had nearly equal access to the operations of multiplicative classification in the concrete situation.

3. The dimensions and operations of additive classification were more operational for the more proficient readers than for the less proficient readers in the concrete situation.

4. Even though the content of reading material may be concrete (familiar to the reader), the reading task within its nature may be more formal or abstract than the concrete manipulative task. Essentially, reading material is more ideational and the ideas are presented in a more logical structured manner. Furthermore, the written language is comprised of greater concept density and the ideas

are organized and contained in larger units of thought (Jenkinson, 1976:61-64; Walker, 1976:146).

## LIMITATIONS

In addition to the limitations cited in Chapter I, the following limitations must be considered in interpreting these findings:

1. The operations and dimensions of classification were primarily assessed in terms of a reading questioning paradigm. That is, the subject was required to read a passage and then answer specific comprehension questions which primarily involved the reader relying on certain dimensions of classification to respond correctly. The extent to which the researcher can make inferences from subject scores to the more general aspects of reading comprehension, which may involve additive and multiplicative classification, is not known.

2. The extent to which the content involved in the passages was novel to the subjects was not known. If the content was novel for the readers, this would have required the subjects to apply these dimensions of classification to an unfamiliar situation. This would make the equivalence of the two tasks, concrete and reading, suspect since then the reading situation would be far more formal and abstract than the concrete situation.

3. The extent to which memory and recall affected the performance of these subjects is not known. An attempt was made to control for this effect by relying on literal comprehension questions and the repetition of information, questions and queries. However,

it is conceivable that the two groups may not have had equal access to all the required information to successfully complete the tasks.

4. A clear criterion of the percentage accuracy required by the subject to indicate mastery or competence of a logical operation was not specified. For example, for a subject to be considered competent in the logical operations of additive classification, the percentage level of accuracy required was not specified by Piaget and thus could not be specified by this researcher. However, an attempt was made by this researcher to establish a relative level of competence by group comparisons.

## IMPLICATIONS OF THIS STUDY

This study has implications for the teaching of reading comprehension.

1. Readers, primarily grade six readers, are capable of the majority of the operations and dimensions of classification. However, these readers, primarily the less proficient readers, may experience difficulty in applying these cognitive abilities to the reading process. The major implication here is that the teaching of reading comprehension should involve teaching children how to apply and extend their mental abilities as strategies for developing reading comprehension (Kachuck and Marcus, 1976:158). This procedure could involve the following general levels: attention to concrete objects, identification of equivalent instances of forms and the discrimination relevant to the attributes of a concept (Kachuck and Marcus, 1976:159; Klausmeir, Ghatala, and Frayer, 1974:6).

Specifically, to teach children how to find part-whole relations and function at the analytic and inferential level of reading comprehension, the following procedures may be useful:

a. Initially use concrete objects to identify relationships. Present the children with a group or collection of objects and ask them to identify the one that represents the whole. Also ask them to explain the reason for the selecting and how the items are related.

b. Present the subjects with a group of pictures of the objects, and again discuss the relationships of the pictures. In addition, ask them to select the picture that most aptly represents all the pictures.

c. In this stage use single words and follow the same procedure as for the first two stages.

d. At this point, extend the use of this skill to short sentences and guide the children in finding key words in these sentences. Here the discussion should focus on distinguishing the main idea of each sentence from the minor details and supporting ideas.

e. The children can be presented with a paragraph and asked to discover what the paragraph is mostly about. At this point the children should be encouraged to apply the same thinking skills used for the initial four steps. Here the main idea and details of the paragraph should be discussed.

The children can also be introduced to the various ways in which the main ideas are conveyed by the author. Jenkinson (1975:2) states the author may use four ways to convey the main ideas. The author may use a deductive procedure and present the main idea in the first sentence. The remaining sentences may contain the supporting concepts. An inductive presentation may be used and the main idea is presented in the final sentence. In an inductive-deductive presentation the main idea is found in the middle of the paragraph with the supporting ideas before and after. In some cases the main idea is not stated directly and the reader must infer, deduce and formulate, for himself, the major concept the author is attempting to convey.

f. In this step the children are presented with a passage comprised of two paragraphs. The children should be informed that an author may use more than one paragraph to present a group of specific ideas to support a main or general idea. The children should be encouraged to find the key words and phrases and discuss how these relate to the main idea.

g. At this stage the children are encouraged to apply this strategy to a selection, story or article which is comprised of more than two paragraphs (Kachuck and Marcus, 1976:159-160).

2. Readers can also be taught to rely on the dimensions of classification to recognize, explicitly, the relationships of ideas and concepts in what they read. The recognition of these relationships can be facilitated through a mapping procedure (Jenkinson, 1975:3). Three schemes, hierarchical sequence, multiplicative structures, and overlapping inter-correlations would be directly related to the operation and dimensions of classification.

Hierarchical sequences essentially consist of relating concepts and ideas in a hierarchical class structure.

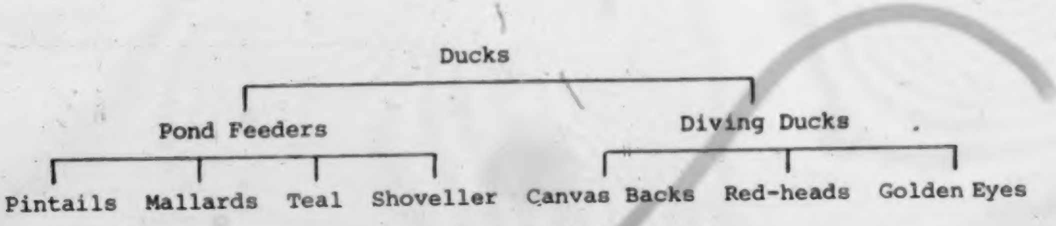

Ducks
Pond Feeders
Diving Ducks
Pintails
Mallards
Teal
Shoveller
Canvas Backs
Red-heads
Golden Eyes

Figure 29

Hierarchical Sequence of Story I (Ducks)

Multiplicative structures are related to linking and expressing ideas in a matrix form.

| | | Soil | |
|---|---|---|---|
| | | Loam | Sand |
| Water | Little | loam soil<br>little water | sandy soil<br>little water |
| | Lots | loam soil<br>lots of water | sandy soil<br>lots of water |

Figure 30

Matrix Structure of Story II (Garden)

Overlapping inter-correlations are related to the linking and expressing of ideas and concepts in simple multiplicative or intersecting form.

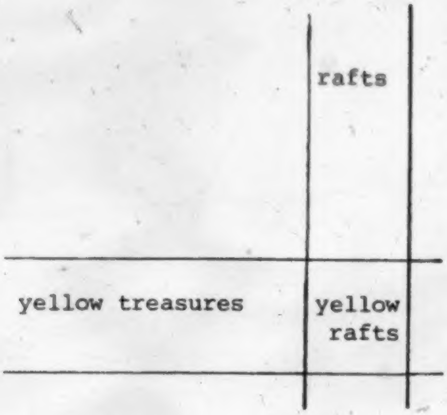


Figure 31

Overlapping Inter-correlations of Story III (City)

## SUGGESTIONS FOR FURTHER RESEARCH

The following suggestions are made for future research:

1. A more systematic control for memory, principally in the dimensions of additive classification, should be considered in all future comparisons between logical operations in a reading and concrete situation. This may be accomplished by allowing the subject to diagram or map out the relationships between the concepts and ideas in a passage. This could also be achieved by presenting the subject with an outline of the basic concepts and ideas presented in the passage and allowing the subject to refer to these in performing the tasks.

2. To more systematically assess the nature of the multiplicative matrix constructed by the subject in terms of stories I and II, the subject could be provided with a diagram of the matrix, after identification of the major multiplicative classes. Through this

procedure it would be more possible to determine the horizontal and vertical as opposed to the diagonal nature of the matrix constructed by the subject.

3. A more systematic analysis and study of the relationship between the concrete operations of classification, and finding the main idea in prose is needed. Essentially, the subject should be required to read a passage in which a group of minor details are presented. The subject should then be requested to formulate a main idea that would include all the minor details. In an attempt to gain further insight into the nature of the logical operations involved in finding the main idea, the subject should be required to provide an explanation. Further study of the relationship between the concrete operations of classification and the heuristics of classification, connectives, and the relating of superordinate and subordinate ideas and concepts is also needed.

4. Further research may also be conducted to assess the extent to which readers can rely on the operations and dimensions of classification to recall what they have read.

5. Future research involving the logical operations of classification may also include different samples, essentially subjects with more advanced cognitive abilities.

## CONCLUDING STATEMENT

The evidence presented in this study suggests that more proficient sixth grade readers are more able to rely on the operations and dimensions of classification in a reading task than less proficient sixth grade readers. This suggests that less proficient readers may require additional instruction in developing and applying these dimensions of classification to a reading task.

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# REFERENCES

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# APPENDICES

# APPENDIX A

## STORY I: THE DUCKS ARRIVE IN SPRING

Story I: The Ducks Arrive in Spring

A. Instructions and Literal Comprehension Questions 1-12
   Literal Comprehension Questions Scoring Criterion

B. Additive Classification Questions
   - Class Construction: I a(1,2), b(1,2), c(1,2)
   - Class Inclusion: II, III, IV
   - Predication: V, VI, VII
   - Class Inclusion: VIII a, b, c, d, e, f

C. Multiplicative Classification Questions: IX(1), X(1),
   IX(2), X(2): Matrix Structure

D. Scoring Criteria
   - Class Construction: I a(1,2), b(1,2), c(1,2)
   - Class Inclusion: II, III, IV, VIII a, b, c, d, e, f
   - Predication: V, VI, VII
   - Matrix Structure: IX(1), X(1), IX(2), X(2)

# STORY I

## THE DUCKS ARRIVE IN SPRING

Every spring the prairies become a fly-way for the birds on their way north for the summer.

The first birds to arrive are ducks, and the first ducks are the pintail. There will be ice on the ponds and lakes and some snow still on the fields when the pintail fly in in April. But these ducks can live off the land. They eat the seeds they find in the yellow stubble of the wheat fields until the ice melts. The pintail come in flocks of hundreds, long black lines of ducks against the blue prairie sky. They circle, then drop into the snowy fields.

The next ducks to arrive are the pond-feeders. They need weedy pools that are not very deep. These are the mallard, teal and shoveller. They swim on the surface of shallow ponds and bob their heads under the water to feed. These ducks must wait for the ice to melt on the shallow pools and ponds. As soon as the ice melted, the pintail will leave the fields and swim about on the pools with the mallard and teal. They are pond-feeders.

The last ducks to arrive are the diving ducks. These are canvas backs, red-head, and golden eyes. Diving ducks must wait for the ice to go out on the lakes and rivers. They dive into deep water to get their food.

## A. INSTRUCTIONS AND LITERAL COMPREHENSION QUESTIONS (1-12):

## THE DUCKS ARRIVE IN SPRING

### Instructions

This is a story about ducks that fly to the prairie in the spring. The story is also about the birds that come to the lakes and ponds of the prairie in the spring. Please read the story and when you have finished I will ask you some questions about what you have read. (Tell me when you have finished.)

Questions (Literal — Check Literal Comprehension Questions Scoring Criterion for queries (Q).)

1. What kind of birds come back first in the spring?
2. What kind of ducks arrive first?
3. What is the weather like when the pintail arrive?
4. How do the pintail get their food when they arrive?
5. Why do they feed off the wheat fields?
6. Where do the pintail feed when the ice melts?
7. Which group of ducks come next after the pintail?
8. Where do the mallard and teal get their food?
9. How do they get their food?
10. What kind of ducks arrive after the mallard and teal?
11. Why do the canvas back and red head come last?
12. Where do they get their food?

## LITERAL COMPREHENSION QUESTIONS

## SCORING CRITERION

1. A statement that includes ducks.

2. A statement including pintail.

3. A statement including any of the following:

    (1) cool

    snowy

    snow on the ground

    (0) icy on the ponds

    cold

4. (1) from the stubble

    off the land

    off the ground

    (0) they eat the seeds from the wheat

    they eat the yellow stubble

5. (1) because it's the only source of food until the ice melts

    have to wait for the ice to melt

    the ice hasn't melted yet

    Q no water to feed on

6. In the ponds or pools must be stated.

    (1) in the ponds

    pools

7. (1) pond feeders

    Q if three or fewer groups stated

8. Ponds must be stated.

   (1) shallow ponds

   the ponds

9. Some statement which includes bobbing.

   bob up and down and duck their heads

   e.g. They bob in and out of the water, like getting their food.

10. (1) diving ducks

11. A statement which suggests that they need deep water for food.

    (1) need deep water for food, have to dive for their food.

    must wait for the ice to go out on the lakes and rivers.

    (0) the ponds would be melted

12. A statement which suggests that they need deep water.

    (1) in deep water

Total Possible Score: 12

## B. ADDITIVE CLASSIFICATION QUESTIONS

### Class Construction

I. One for each (tell me some more or repeat)

(a) How are ducks different from other birds? How are they similar to other birds?

(b) How are birds different from other animals? How are they similar to other animals?

(c) How are the pintail different from the other ducks? How are they similar to other ducks?

### Class Inclusion

II. Are there more ducks or more pintails here on the prairie in the summer? How do you know that? Why is that? How else can you be sure of your answer? Are pintails ducks? (If general answer wrong and the last answer is correct repeat the question.)

III. Are there more animals or more birds in the world? How do you know that? Why is that? How else can you be sure of it? Are birds animals? (If general question wrong and the last answer is correct repeat the question.)

IV. If all the birds left the prairie and flew into the far north would there be some ducks here on the prairie? How do you know that? Why is that? How else could you know that?

### Predication

V. I want you to tell me about the "kinds" of ducks that come to the prairie. Put all the ducks you read about into two different groups or lots. You can do this without using their names. Describe them.

(Q) Divide all the ducks that come back into two groups and describe the groups.

If the response is to list names the examiner replies, Can you describe them? What groups of ducks come back in the spring? Put them all into two lots.

VI. Tell me another way to describe the kinds of ducks that come back in the spring. Put all the ducks that come to the prairie into two different groups or lots in another way and describe them.

(Q) Divide all the ducks that come back into two groups and describe the groups.

If the response is a name rather than a predicate, for example "mallard" the examiner replies: Can you describe them? What are the kinds of ducks that come back in the spring?

VII. There is still another way to describe the kinds of ducks that come back in the spring. Put all the ducks into two lots in another way and describe them.

(Q) Divide all the ducks that come back into two groups and describe the groups.

If the response is a name rather than a predicate, for example "mallard" the examiner replies: Can you describe them? What are the kinds of ducks that come back in the spring?

Class Inclusion

(If response is, it said in the story:
Q(1) Why else would you say that.
(2) Tell me more.)

VIII. (a) In this group of ducks are some of the pond feeders mallards? Why do you say that?

(b) In these groups of ducks are some of the diving ducks red heads? Why do you say that?

(c) If you went to a lake and saw a diving duck will it have to be a canvas back? Why would you say that?

(d) If you went to a pond and saw a pond feeder will it have to be a pintail? Why do you say that?

(e) If you saw a teal, would the duck have to be a pond feeder? Why would you say that?

(f) If you saw a canvas back would the duck have to be a diving duck? Why would you say that?

## C. MULTIPLICATIVE CLASSIFICATION QUESTIONS:

### MATRIX CLASS STRUCTURE

IX. (1)
X. (1) You're driving along the highway and you see shallow ponds along the road and you see a lake not far away. What kinds of ducks will live in this neighbourhood? (Tell me the major kinds of ducks that will live there. Why would you say that?)

If identifies one multiplicative class (Q go on).
If response less than type V, give question IX(2), X(2).

IX. (2)
X. (2) Remember some ducks live in ponds and some ducks live in lakes. Also remember that some ducks get their food from the surface of the water and some ducks get their food from the bottom.

Now if you're driving along the road and you see shallow ponds and a lake not far away, what kinds of ducks will live in this neighbourhood? Why would you say that?

If identifies one multiplicative class (Q go on).

## D. SCORING CRITERIA

Class Construction: I. a(1,2), b(1,2), c(1,2)

General

The three specific criteria (a, b, c) are assumed to have been met if the correct superordinate and subordinate properties are identified.

(a) all elements are classified

(b) class $B_1$ includes directly all the elements having the property $b_1$

(c) class $B_1$ includes directly only the elements having the property $b_1$.

(a, b, c are also applicable to $B_2$, $B_3$)

Class Construction

I. If initial response 0, one Q (tell me more).

a(1) One clear attribute directly or indirectly confined to the subordinate class $A_1$. (All ducks have that property.)

(1) e.g. make a different sound from other birds
swim in the water and quack

(0) e.g. come first
big beaks

a(2) One clear attribute directly or indirectly confined to the superordinate class $B_1$. (All birds have that attribute.)

All have feathers, beak, tail

(1) e.g. they can fly

b(1) One clear attribute directly or indirectly confined to the subordinate class $A_2$. (All birds have that attribute.)

(1) e.g. they can fly and some other animals can't

(0) e.g. smaller than some other animals

b(2) One clear attribute directly or indirectly confined to the superordinate class $B_2$. (All animals have that attribute.)

(1) e.g. have eyes
can hear
they're animals
breath air

(0) e.g. get their food on the ground
feed off other animals
similar because they lay eggs
swim

c(1) One clear attribute directly or indirectly confined to the subordinate class $A_3$. (All pintails have that attribute.)

(1) e.g. land in the snowy fields in April
come before the rest of them
they get their food off the surface of the water.

(0) e.g. their shape
come later than the first ducks

c(2) One clear attribute directly or indirectly confined to the superordinate class $B_3$. (All ducks have that attribute.)

(1) e.g. they can fly
has feathers and wings
well they're just like the other ducks and they all fly and they all eat and get their food from the water
they are ducks

(0) e.g. they go under the water

Total Possible Score: 6.

Class Inclusion: II, III, IV, VIII a, b, c, d, e, f

II. Statement must include more ducks and some major indicator of inclusion. A major indicator of inclusion can be any of the following:

(a) that there are other ducks ($A'$) and a "yes" response to the final question.

(b) the response that "pintails (A) are ducks (B)."

(1) e.g. more ducks
because pintails are ducks
ducks, because there are a whole bunch of other ducks not just the pintail, yes
more ducks, because pintails are only one third of the duck species, yes
more ducks because pintails are pondfeeders and there's diving ducks, yes
more ducks, well I see lots of ducks at our cabin, and I'm looking at the lake, yes

(0) e.g. more ducks, because pintails they need to have wheat and that, no

III. Statement must include more animals and some major indicator of inclusion. A major indicator of inclusion can be any of the following:

(a) that there are other animals ($A'$) and a "yes" response to the final question.

(b) the response that birds (A) are animals (B).

(1) e.g. animals, because birds are animals
more animals, because there's hundreds of kinds of animals all over the world, yes
more animals, there are more different species of animals in the world, birds are just sparrows, ducks and so yes
more animals because there are many more different classes of animals than there are birds, yes
more animals, because there are a lot of kinds of animals out in the forest, yes

(0) e.g. more animals, well there's so many in Africa, no
more birds, they're many species and they usually multiply fast, yes

IV. Statement must include "no" to the main question, and some major indicator of inclusion. A major indicator of inclusion involves some reference to B (birds, they) and some indication that A (ducks) is part of B (birds).

(1) no, if they all fly south, they would go too
no, because ducks are birds and if they all fly away that means that ducks to fly away
no, because you said all of the birds fly north
no, because if all the birds went to the north pole and ducks are birds they'd have to go too

(0) yes, because some of them only go someplace in the south
yes, there would be some, because not all of them fly

VIII. (Q can you tell me more) if response is, "read it in the story."

(a) Statement must include "yes" and some major indicator of inclusion. A major indicator of inclusion is that A (mallards) are B (pondfeeders). B (pondfeeders) can be characterized by:
(1) time of arrival—later in the spring
(2) habit—feed off the surface
(3) habitat—live in ponds

(1) yes, because they're the same kind if they're pondfeeders
yes, when the ice melts they go where the other groups are to feed in the ponds
yes, because they come later in the spring

(0) yes, I just guessed
yes, because a pondfeeder is a mallard
yes, because mallards are ducks

(b) Statement must include "yes" and some major indicator of inclusion. A major indicator of inclusion is that A (red heads) are B (diving ducks). B (diving ducks) can be characterized by:
(1) time of arrival—late, when the ice is gone
(2) habit—feed off the bottom, dive for food
(3) habitat—live in lakes, rivers, deep water

(1) yes, because they dive under the water to get their food

(0) yes, I think they are red heads
yes, because diving ducks do have red heads

(c) Statement must include "no" to the main question and some major indicator of inclusion. A major indicator of inclusion involves some indication that it could be any kind of duck (A') or any kind of diving duck (A').

(1) no, you could see any kind of duck on the lake
no, it could be a different kind of duck
no, because there's all kinds of ducks
no, because not every duck is one

(0) yes, well canvas back is the ones that dive deep

(d) Statement must include "no" to the main question and some major indicator of inclusion. A major indicator of inclusion involves some indicator that it could be any kind of duck or any kind of pondfeeding duck (A').

(1) no, because after ducks feed in the ponds it could be a mallard
no, because the mallard, pintail and canvas back, and the other kinds they all feed off the pond when the ice melts
no, because there are other ones

(0) no, because a pondfeeder isn't a pintail
yes, because it belongs to that group of ducks

(e) Statement must include "yes" to the main question and some major indicator of inclusion. The major indication is that a teal (A) is a pondfeeder (B).

(1) yes, a teal is like a pondfeeder
yes, because it said in the story that they come with the mallard and that they were pondfeeders
yes, because they come earlier in the spring

(0) no, because a pondfeeder isn't a pintail
no, because they're not the same

(f) Statement must include "yes" to the main question and some major indication of inclusion. The major indication of inclusion is that a canvas back (A) is a diving duck (B).

(1) yes, because it is a diving duck
yes, because they come when the lakes have melted
yes, because it's classified under the section diving duck and not pondfeeder
yes, because it only comes in the summertime

(0) no, it might just be some kind of other duck
yes, the diving ducks are canvas backs
no, it could be a pintail duck

Total Possible Score: 9

**Predication:** V, VI, VII

In general the groups of ducks can be grouped on the basis of three major attributes. The attributes are defined in terms of the story. Three main criterion categories or collections are possible, $B_1$, $B_2$, $B_3$, with six dichotomous classes ($A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$).

$B_1$, $B_2$, $B_3$ can be either Time, Habitat, or Habit, however $B_1 \neq B_2 \neq B_3$.

(1) $B_1$ = Time

e.g. $A_1$ = early

$A'_1$ = late

(2) $B_2$ = Place (habitat)

e.g. (a) $A_2$ = ponds

$A'_2$ = lakes

(b) $A_2$ spend most of their time on the land, and

$A'_2$ ducks that spend most of their time in the water

(3) $B_3$ = Habit

e.g. (a) $A_3$ surface feeders

$A'_3$ diving ducks

or (b) $A_3$ pondfeeders

$A'_3$ diving ducks

(c) $A_3$ live off the land

$A'_3$ live off the water

(d) $A_3$ warmer weather

$A'_3$ colder weather

(e) $A_3$ feed off the lake

$A'_3$ don't feed off the lake

(f) $A_3$ dive for their food

$A'_3$ don't dive for their food

(g) $A_3$ the ones that feed off the stubble and

$A'_3$ the ones that feed off the water

(4) All collections or categories formed must be identified as either habitat ($B_1$), habit ($B_2$) or time of arrival ($B_3$). In addition, the attributes must have been identified in the story.

(NR no response) (NR no response)

(Repetition is a direct paraphrase and the same major criterion is used.)

I. Response, however none of the three major criteria or collections ($B_1$, $B_2$, $B_3$) are identified.

e.g. I'd put the first and second group together because they feed off the ice and the third and fourth so that's why they're together.

II. States the properties of two collections however the collections are not mutually exclusive and no one distinct criterion is stated.

e.g. there's the kind that live off fish and there's the kind that live off wheat, the pondfeeders they eat fish all the time

there's the pintail and the pondfeeders, the mallards and the teal, I mean the pondfeeders and ____

III. States one principal criterion or collection $B_1$, $B_2$, $B_3$ and forms one class (no repetitions). Only one class $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$ is stated, and the other class is not stated or described.

e.g. the pondfeeders wouldn't be as much for swimming under the water, they'd be more for just on top

there is the ducks that feed in the pond some of the time

IV. States a principal criterion or collection $B_1$, $B_2$ or $B_3$ and forms one class (the class is repeated) ($A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$)

e.g. V. pondfeeders and diving ducks, some feed off the surface and some dive to feed. (Type V response.)

VI. diving ducks

VII. pondfeeders

V. States one principal criterion or collection $B_1$, $B_2$ or $B_3$ and forms two dichotomous classes (no repetitions) ($A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$).

e.g. one group of ducks come where there is still ice on the ponds and the other doesn't come until the ice is gone
(main criterion time of arrival)

some ducks get their food from deep water and some get their food from just shallow ponds
(main criterion habitat)

VI. States a principal criterion or collection $B_1$, $B_2$, $B_3$ and forms two dichotomous classes (the two dichotomous classes are repeated) ($A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$).

e.g. V. the ones that come back in the winter when the ice is still on the lakes, and the ones that come in during the summer

VI. some come back in early spring and some come back later

VII. come back in the winter and some come back in the spring

Scoring

I = 0
II = 0
III = 1
IV = 0
V = 2
VI = 0

Total Possible Score: 6

Matrix Structure: IX(1), X(1), IX(2), X(2)

Major Collections $B_1$, $B_2$, $B_3$ and Dichotomous Classes $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$

(1) Feeding habit ($B_1$): any correct statement of a feeding habit is considered a major attribute of a dichotomous class of the major collection.

$A_1$ surface feeders

$A'_1$ diving ducks

$A_1$ feed on top of the water

$A'_1$ diving ducks

$A_1$ bobbing ducks

(2) Habitat ($B_2$): any correct mention of where the ducks live is considered a major attribute of a dichotomous class of the major collection.

| | | | |
|---|---|---|---|
| $A_2$ | live in ponds | $A_2$ | feed in ponds |
| $A'_2$ | live in lakes, rivers, etc. | $A'_2$ | feed in lakes |
| $A_2$ | live in shallow water | | |
| $A'_2$ | live in deep water | | |

(3) Time of arrival ($B_3$): any correct mention of when the ducks arrive is considered a major attribute of the dichotomous class of the major collection.

$A_3$ arrive early when there's still ice on the ponds

$A'_3$ arrive later when the ice is gone

$B_1 \neq B_2 \neq B_3$

Major Multiplicative Classes of Ducks

(1) diving ducks

(2) surface feeders

(3) feed on the surface and live in the ponds

(4) mallard, teal, shoveller

(5) pondfeeders

(6) pintails

(7) dive for food and live in lakes

(8) convas backs, red head, golden eyes

e.g.

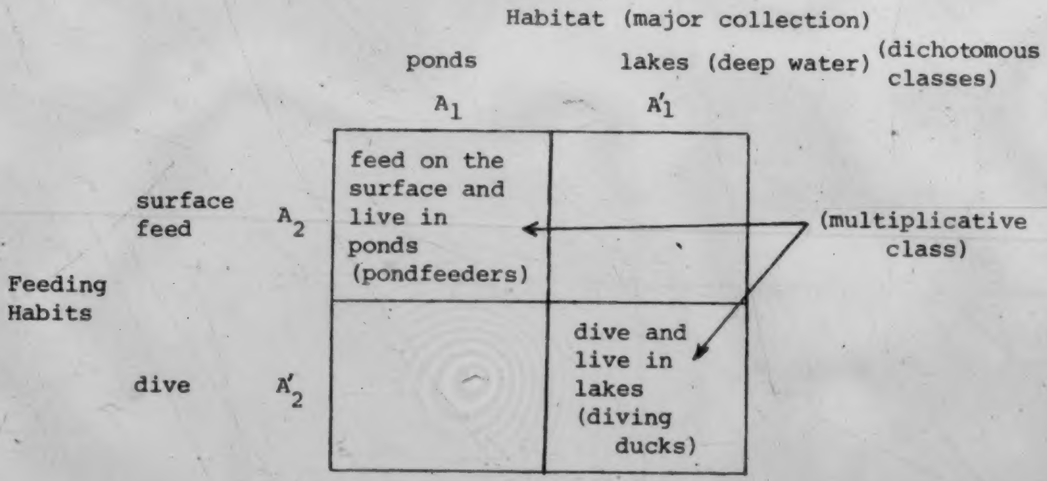

Habitat (major collection)
ponds
lakes (deep water)
(dichotomous classes)
$A_1$
$A'_1$
feed on the surface and live in ponds (pondfeeders)
surface feed
$A_2$
(multiplicative class)
Feeding Habits
dive
$A'_2$
dive and live in lakes (diving ducks)

Figure 32

Example of Multiplicative Classes Formed through Major Dichotomous Classes, and Major Collections

I. No response

II. None of the major collections are stated, $B_1$, $B_2$, $B_3$, none of the dichotomous classes are stated, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$ and none of the multiplicative classes are stated. (1-8)

III. Only one major collection is stated: either $B_1$, $B_2$ or $B_3$.

e.g. ducks that feed in water, ducks that just swim in it

feed in water = $B_2$

III. (a) Only the two main collections are stated: two of either $B_1$, $B_2$ or $B_3$.

III. (b) Only one major collection is stated, either $B_1$, $B_2$ or $B_3$ and one or more of the corresponding dichotomous classes is stated, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$.

III. (c) Two major collections are stated, either $B_1$, $B_2$ or $B_3$ and one or more of the corresponding dichotomous classes of each of the major collections is stated, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$.

IV. Only one major multiplicative class is identified, either of (1-8). The major collection $B_1$, $B_2$, $B_3$ is not stated and the dichotomous class is not stated, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$.

e.g. diving ducks, red heads, and duck ducks and canvas because they're near ponds and ducks are attracted to water

$A'_1A'_2$ = diving ducks

pondfeeders and mallards, because it said the mallards are pondfeeders

$A_1A_2$ = pondfeeders

IV. (a) Only one major multiplicative class is stated, either of (1-8), at least one of the dichotomous classes of the major collections is stated, $A_1$, $A'_1$, $A_2$, $A'_2$ $A_3$, $A'_3$, and the major collection is stated, $B_1$, $B_2$, $B_3$.

e.g. pondfeeding, because they live close to ponds

($A_1A_2$ = pond feeding)

$A_1$ = ponds $B_2$ = live close to ponds (habitat)

diving ducks, because when the ice melts they go to the lake and the deeper water where they live in to have their food, they dive in deep water for their food

V. Only two multiplicative classes are identified (two from 1-8), only one major collection, $B_1$, $B_2$ or $B_3$, is stated and one of the dichotomous classes of the major collection is stated, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$.

e.g. there would be pondfeeding ducks and the first group diving ducks because it's shallow water

$A_1A_2$ = pondfeeding $B_2$ = habitat $A_2$ = shallow water

$A'_1A'_2$ = diving ducks

pintail, diving ducks, the feed eaters

pintail and the feed eaters that's where they hang around to get their food, because it's shallow

V. (a) Two multiplicative classes are stated (1-8) and at least one major collection is stated, $B_1$, $B_2$ or $B_3$. One or more, but not all four, dichotomous classes of the major corresponding collections, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$ are stated.

e.g. pondfeeders and diving ducks because pondfeeders feed on ponds and diving ducks feed on lakes.

$A_1A_2$ = pondfeeders $A'_2$ = feed on lakes
$A'_1A'_2$ = diving ducks $A_2$ = feed on ponds
= $B_2$ habitat

pintails and diving ducks, because there's a pond and a lake, because the pintails feed in the ponds and the diving ducks feed in lakes

V. (b) Two multiplicative classes are stated (1-8), and the two major collections are also stated (any two of $B_1$, $B_2$ and $B_3$). The two dichotomous classes for each of two major collections are also stated.

e.g. deep divers, deep diving ducks and pondfeeders, because in the lake the deep divers could go down into the deep water there, and in the shallow ponds the ponds where the teal and mallard would go, because they're shallow and they get their food off the surface.

$A_1A'_2$ = deep diving ducks $A'_2$ = lakes
$A'_1A_2$ = pond feeders $A_2$ = shallow ponds
= $B_2$ habitat

$A_1$ = go down into deep water
$A'_1$ = get their food off the surface
= $B_1$ feeding habits

Scoring

I-III(c) = 0
IV-IV(a) = 1
V-V(b) = 2

Total Possible Score: 2

If reponse less than V, give question IX(2), X(2).

# APPENDIX B

## STORY II: JIM AND HIS GARDEN

Story II: Jim and His Garden

A. Instructions and Literal Comprehension Question 1-5
   Literal Comprehension Questions Scoring Criterion

B. Multiplicative Classification (Matrix Class Structure)
   Questions 1-2
   Multiplicative Classification (Matrix Class Structure)
   Scoring Criterion Questions 1-2

## STORY II

## JIM AND HIS GARDEN

Today is Saturday and what a beautiful spring day! The grass is green and the buds of the trees are just starting to open. Today would be a perfect day to plant the vegetable garden, thought Jim, as he ran downstairs for breakfast. Just yesterday he had examined the many seeds that he wanted to plant.

While eating breakfast he decided that he would plant cabbage, lettuce, beets, carrots, beans, peas, potatoes, tomatoes and onions. As he read the planting instructions for the seeds he noticed that some of the vegetables would require sandy soil to grow well. The rest of the vegetables would grow well in loam. What fun he thought as he went to the garage for his hoe and rake. As he was raking and weeding the two large loam and two large sand plots he remembered that some of the vegetables would require a lot of water to grow well. The rest of the vegetables would need only a little water to grow well. As he worked he thought of how well the vegetables would grow. The summer, as usualy, would be hot and there would be little rain. He would of course, have to water the plants, but since he had a sprinkler and a large watering can this would not be too difficult.

## A. INSTRUCTIONS AND LITERAL COMPREHENSION

## QUESTIONS (1-5):

## JIM AND HIS GARDEN

### Instructions

This is a story about Jim and his vegetable garden. Please read the story and when you have finished I will ask you some questions about what you have read. (Tell me when you have finished.)

### I. Questions (Literal)

1. What did Jim decide to do today?
2. Name three vegetables that Jim plans to plant.
3. What types of soil did the vegetables need to grow well?
4. Describe the amount of water the plants will need to grow well.
5. How is Jim going to water the plants?

## LITERAL COMPREHENSION QUESTIONS

## SCORING CRITERION

1. A statement of Jim deciding to plant a vegetable garden.

   (1) plant a vegetable garden

2. Any three vegetables (cabbage, lettuce, beets, carrots, beans, peas, potatoes, tomatoes, onions).

   (1) cabbage, beats, tomatoes

3. A statement indicating loam and sandy soil (both must be given).

   (1) sandy soil and loam soil

   (0) wet soil

4. A statement indicating that some will need a lot of water, and the rest will need a little water (both must be given).

   (1) some would need a little and some would need a whole lot

   (0) a little, some everyday

5. A statement comprised of both watering can and sprinkler. watering can (water bucket)

   (1) with a sprinkler and a watering can

   (0) with a sprinkler and one of those handle things

Total Possible Score: 5

## B. MULTIPLICATIVE CLASSIFICATION (MATRIX CLASS STRUCTURE)

### QUESTIONS 1-2

II. Questions (Matrix)

1. Describe how Jim can plant his garden so that all the plants will get the proper soil and the proper amount of water to grow well. Why do you say that?

   If not a VIIa response, give question 2.

2. Remember Jim has vegetables that need sandy soil and vegetables that need loam. Jim also has vegetables that need a lot of water and he has vegetables that need a little water to grow well. Now, describe how Jim can plant his garden so that all the plants will get the proper soil and the proper amount of water to grow well. Why do you say that?

## MULTIPLICATIVE CLASSIFICATION (MATRIX CLASS STRUCTURE)

## SCORING CRITERION

### Major Collections, $B_1$, $B_2$, and Dichotomous Classes, $A_1$, $A'_1$, $A_2$, $A'_2$

1. Soil (dirt) = $B_1$

   $A_1$ = sandy soil

   $A'_1$ = loam soil

2. Water = $B_2$

   $A_2$ = little watering

   $A'_2$ = a lot of watering

### Major Multiplicative Classes ($A_1A_2$ . . . )

1. sandy soil, little water
2. sandy soil, a lot of water
3. loam, a little watering
4. loam, a lot of watering

| | | $B_2$ water | |
|---|---|---|---|
| | | Little watering $A_2$ | A lot of watering $A'_2$ |
| $B_1$ Soil | Sandy soil $A_1$ | little water<br>sandy soil | a lot of water<br>sandy soil |
| | Loam soil $A'_1$ | little water<br>loam soil | a lot of water<br>loam soil |

Figure 33

Example of Multiplicative Classes Formed Through Major Dichotomous Classes and Major Collections

## Response Types

I. No response.

II. None of the major collections are stated, $B_1$, $B_2$, none of the dichotomous classes stated, $A_1$, $A'_1$, $A_2$, $A'_2$, and none of the multiplicative classes are stated (1-4).

III. Only one major collection is stated, either $B_1$ or $B_2$.

e.g. he can plant all the vegetables in one row like all carrots in one row and if he needs soil he could just put it in, put one vegetable in one row and the other in different rows

$B_1$ = soil

III. (a) Only the two main collections are stated, $B_1$ or $B_2$.

e.g. he could mix the soil and he could put medium type water because then they'd be getting the right kinds of soil and water

$B_1$ = soil

$B_2$ = water

III. (b) Only one major collection is stated, either $B_1$ or $B_2$, and one or more of the corresponding dichotomous classes is stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

e.g. half of his garden would be loam soil and the other would be sandy. He would plant all the plants that need loam soil in one half of the garden and the other half in rows, because if he would put the sand vegetables in the loam they wouldn't grow, and the loam plants wouldn't grow well in sand, he'd have to do that if he wanted a good garden

$B_1$ = soil

$A_1$ = loam soil

$A'_1$ = sandy

III. (c) Two major collections are stated, $B_1$ and $B_2$, and one or more of the corresponding dichotomous classes of each of the major collections is stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

e.g. he can plant all the same vegetables in one row like all carrots in one row, and if he needs soil he could just put it in, put one vegetable in one row and the other in different rows and water them how they need to be water, to me it seems logical or plant them in different sections. Well plant one that needs sandy soil in one and one who needs little watering in the other.

$B_1$ = soil    $A_1$ = sandy soil
$B_2$ = water    $A_2$ = little watering

well he could divide the garden up into parts, one part could be soil for plants that require special soil like sandy soil and another section could be for plants that need a lot of water and the next could be for the plants that hardly need any water at all and there could be another section for the regular soil, loam soil

IV. Only one major multiplicative class is stated, either of (1-4). The major corresponding collection is not stated, $B_1$, $B_2$, and the corresponding dichotomous class is not stated, $A_1, A'_1, A_2, A'_2$.

IV. (a) Only one major multiplicative class is stated, either of (1-4). At least one of the dichotomous classes of the major collections is stated, $A_1, A'_1, A_2, A'_2$, and the corresponding major collection is stated, $B_1$, $B_2$.

V. Only two multiplicative classes are stated (two from 1-4), only one major corresponding collection, $B_1$, $B_2$, is stated, and one of the dichotomous classes of the major corresponding collections is stated, $A_1, A'_1, A_2, A'_2$.

V. (a) Only two multiplicative classes are stated (1-4). At least one major collection is stated, $B_1$, $B_2$, and one or more but not all four of the corresponding dichotomous classes, $A_1, A'_1, A_2, A'_2$ of the major corresponding collections are stated.

V. (b) Only two multiplicative classes are stated (1-4) and the two major corresponding collections are also stated, $B_1$, $B_2$. The two dichotomous classes, $A_1, A'_1, A_2, A'_2$ for each of the two major collections are also stated.

e.g. he can divide it into two sections, make one with sandy soil and the other with loam soil and the sand soil if it needs a lot of water or a little water he could just put the sprinkler there and put it on low so it doesn't go into the other section and the other section he can water as much as it needs.

| | |
|---|---|
| $A'_1A'_2$ | sand soil, a lot of water |
| $A_1A_2$ | sand soil, a little water |

$A'_1$ = loam soil $B_1$ = soil
$A'_1$ = sand soil

$A'_2$ = a lot of water $B_2$ = water
$A_2$ = a little water

VI. Only three major multiplicative classes are stated (1-4), however all the corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$, are not stated, and all the corresponding major collections, $B_1$, $B_2$, are also not stated.

VI. (a) Only three major multiplicative classes are stated (1-4), all the corresponding dichotomous classes of the major collections are stated, $A_1$, $A'_1$, $A_2$, $A'_2$ and all the major corresponding collections are stated, $B_1$, $B_2$.

VII. The four major multiplicative classes are stated (1-4), all the corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$ of the major collections, $B_1$, $B_2$, are not stated and the two major corresponding collections $B_1$, $B_2$ are also not stated.

VII. (a) Four major multiplicative classes are stated (1-4), all the corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$ of the major collections $B_1$, $B_2$ are stated and the two major corresponding collections are also stated, $B_1$, $B_2$.

e.g. well divide it into sections like if a part of a, let's say two vegetables (1) need sandy soil and well watering divide them, and if one needs (2) loam and just a little water then divide it into another section and if one needs (3) sandy soil and little watering divide it, and if (4) one needs loam and well water just divide it.

$A_1A'_2$ = sandy soil and well watering
$A'_1A_2$ = loam and just a little watering
$A'_1A'_2$ = loam and well watering
$A_1A_2$ = sandy soil and little watering

$A_1$ = sandy soil $B_1$ = soil
$A'_1$ = loam soil

$A'_2$ = well watering $B_2$ = watering
$A_2$ = little watering

**Scoring**

I-IIIc = 0
IV- IVa = 1
V- Vb = 2
VI- VIa = 3
VII-VIIa = 4

Total Possible Score: 4

# APPENDIX C

## STORY III: A CITY OF LONG AGO

Story III: A City of Long Ago

A. Instructions and Literal Comprehension Questions 1-7
   Literal Comprehension Questions Scoring Criterion

B. Multiplicative Classification (Intersection)
   Questions 1-2
   Multiplicative Classification (Intersection)
   Scoring Criterion Questions 1-2

## STORY III

## A CITY OF LONG AGO

Many thousands of years ago, there lived a people in India who built beautiful cities. Their streets were straight, like ours, and the streets met at corners like ours. But these people made a long curve at the corner of their streets and built a house there. So this house on the corner belonged to both streets. It looked up one street and it looked down the other. It belonged to both streets.

People came from far away to live on the streets of this beautiful city. Some families came down the river on rafts from their villages in the mountains. Some families travelled on foot for many days through the forests. Every family who came on foot carried some small treasure to remind them of their old homes.

In the strange new city families from the same village liked to live near one another, to be near their friends. So it happened that everyone along one street came from the same village. They had travelled together for many days through the forest. And everyone along the other street had come together down the river on rafts from their village in the mountains.

The forest people set out their treasure in front of their houses. These were treasures they had carried with them from their old homes. Every treasure was painted a bright yellow color to show how happy the family was to reach the great city. There was an old church bell in front of one house. It was painted bright yellow. An old axe was in front of another house. It was bright yellow, too. In front of another house there was a tall post carved with the strange signs the people used for letters in those days. It was yellow, too. Every house had its bright yellow treasure set out in front for all to see.

In front of every house on the other street was the family's old waterlogged raft. They had come down the river on that raft, and they treasured it. They wanted everyone to see it, just as it was. All along this street was a row of river rafts.

There was only one house that had no treasure set out in front for all to see. That was the house at the corner which belonged to both streets. It looked up the street with all the yellow treasures and down the street with all the rafts.

## A. INSTRUCTIONS AND LITERAL COMPREHENSION

## QUESTIONS (1-7):

## A CITY OF LONG AGO

Instructions

This is a story about a city that was built by people in India a very long time ago. It was a beautiful new city and many people came to live there. Please read the story and when you have finished I will ask you some questions about what you have read. (Tell me when you have finished.)

I. Questions (Literal)

1. How did the people travel who came down the river?
2. What is a raft?
3. When the people who travelled down the river on rafts reached the city where did they put the rafts? Why did they do that?
4. Other people came on foot through the forest. What treasures did they carry with them?
5. Where did these people put their treasures?
6. What color did they paint them?
7. Why did they paint them yellow?

# LITERAL COMPREHENSION QUESTIONS

## SCORING CRITERION

1. A statement indicating that the people travelled by raft.

   (1) on rafts

2. Statement must include some definition of a raft. Can be defined functionally, by example, or descriptively.

   (1) its sorta like a platform made of logs and tied together
   a ship made of logs

3. (a) A statement indicating that the raft was:

   (1) put in front of their houses

   (0) outside their house

   (b) A statement indicating that the people treasured the rafts or they wanted everyone to see them.

4. The statement, treasures, and a list of at least one of the treasures mentioned in the story.

   (1) treasures they put in front of their house an old church bell, an old axe, a tall post

5. A statement indicating that the treasures were put in front of their houses.

   (1) in front of their houses

6. A statement indicating that they were painted yellow.

   (1) yellow

7. A statement indicating that the people wanted to show that they were happy to reach the great city.

   (1) to show that they were happy

Total Possible Score: 8.

## B. MULTIPLICATIVE CLASSIFICATION (INTERSECTION)

### QUESTION 1-2

II. Questions (Intersect)

1. What could the family who lived in the house on the corner, put out for everyone to see? They wanted to put out one thing to show that they belonged to both streets because they lived where the two streets met. What should this family put out. (If response is more than one thing— Q only one thing.) Why do you say that?

   If not a VIII response, give question 2.

2. You remember there was only one house that had no treasure set out in front for all to see. That was the house at the corner which belonged to both streets. It looked up the street with all the yellow treasures and down the street with all the rafts. What should this family put out for everyone to see? They wanted to put out one thing to show that they belonged to both streets because they lived where the two streets met. What should this family put out? Why do you say that?

## MULTIPLICATIVE CLASSIFICATION (INTERSECTION)

## SCORING CRITERION

Multiplicative Classes $A_1A_2$.

1. $A_1$ and $A_2$ can be any of the following, but $A_1$ is not equal to $A_2$.

   e.g. $A_1$ rafts

   $A_2$ yellow treasures

   e.g. something that is treasured
   it would be yellow because it's something they treasured
   treasures (an old church bell, an old axe, a tall post)

2. $A_1A_2$: The statement must contain raft and yellow, and the two attributes must be related.

   e.g. rafts painted yellow
   a raft painted yellow
   a painting of a raft painted yellow

   (Note: the raft must be totally yellow, not half yellow.)

Response Types

I. No response

II. The object, objects or collection stated matches only one collection and is one or more of the elements in the collection (either $A_1$ of $A_2$).

   e.g. a bell to show that the house was on two streets
   treasures

   e.g. well they could put stuff out where they looked up the road and they didn't put nothing out where they looked down the road, because if they looked down nobody can see the treasures. If they looked up people could see the treasures.

II. (a) The object stated does not match or is not in any of the major collections $A_1$ of $A_2$, and has no direct relation to any of the collections.

   e.g. a sign that says that they belong to the two of them because the people were wondering why it was the only one on the corner and it would tell them why it belonged to both sides of the street.

III. The object stated is not in one of the collections, and it has a functional relation with one or more of the elements in one collection ($A_1$ or $A_2$).

e.g. a paint brush, because it can be used to paint the treasures

IV. The object stated is not present already, but it clearly resembles the elements of one collection (either $A_1$ of $A_2$).

e.g. maybe just a boat with the sides on it, well because it's more than a raft and it's less than a treasure

V. The subject does not rely on only one element but rather states two. Two objects are stated, one from $A_1$ and one from $A_2$.

e.g. a raft and another treasure

VI. The object chosen is a simultaneous function of the two collections, however the choice is made in terms of a functional relation, or a partitive relation. The chosen element is not already present.

e.g. a paintbrush and broom combined because it can be used to paint the treasures yellow and the broom because it can be used to sweep the rafts

See: Piaget and Inhelder (1964:183).

Ala (7;11)
(on one side leaves and the other side green objects, including an axe)

a tree because it goes with the axe and the leaves

VII. The object stated is not present already, and both collections are considered ($A_1$, $A_2$), however only genus is used and not differentia. Bears some degree of resemblance to the elements of both collections ($A_1$, $A_2$), however the similarities are too broad. Usually confined to some of the elements and does not extend to them all.

VIII. Multiplication of Classes: An explicit reference to all and not to any one particular element. States the common properties of $A_1$ and of $A_2$ and then state how the properties of $A_1A_2$ relate to $A_1$ and $A_2$. Also states $A_1A_2$.

e.g. a raft painted yellow, $A_1A_2$, because one side of the street they wanted rafts, $A_1$, because there were rafts and on the other side they wanted the yellow treasures, $A_2$, so it would be both.

Scoring

I-VII = 0
VIII = 1

Total Possible Score: 1

# APPENDIX D

## STORY IV: THE TWINS

Story IV: The Twins

A. Instructions and Literal Comprehension Questions 1-6
   Literal Comprehension Questions Scoring Criterion

B. Multiplicative Classification (Intersection)
   Questions 1-2
   Multiplicative Classification (Intersection)
   Scoring Criterion Questions 1-2

## STORY IV

## THE TWINS

The Adams have two children who are twins. The twins' names are John and Mary. June 17th will be the twins' birthday and the Adams wished to give Mary and John a gift that both the children would like.

John is in grade seven. He likes to read books and play hockey. He also likes dogs. Just last week John's team won the last game of the season. This win guaranteed the team a position in the semi-finals. If they won the local championship the team would go to Ottawa and play for the final national championship.

John also likes to read many books. He enjoys reading mysteries and books about hockey. Recently he began to read some science fiction books. Many times he had told his mother and father how much he enjoyed reading science fiction. He loved to make believe that he was travelling to a distant star in his very own space ship.

The Adams recall that John has frequently mentioned that he would like a large black dog. Many times John had told them about Randy's dog, Pete. Pete was a big black dog. He loved to fetch and he was always with Randy.

Randy, who was John's best friend, went to the same school as John. He was also in grade seven and played on the same hockey team as John. Together they played on the same forward line.

Mary, John's sister, was also in grade seven. She likes to make her own clothing, paint and play volleyball. Most of all she loved animals. Frequently she would look after the neighbors' dog when they would leave for the weekend. Mary really looked forward to this because she loved their large white long haired dog. Many times Mary had mentioned that she wished that she could have a large white long haired dog.

Mary also enjoys making her own clothing. Sometimes she would spend hours looking through magazines and catalogs hoping to find some new ideas. When she found an outfit she liked, she would urge her mother to buy the material and pattern so that Mary could make the outfit.

Mary also likes to paint. After school when she was not playing volleyball, Mary would go to art classes. Here she learned how to draw and paint people. She also learned how to paint and draw animals and landscapes. In addition to drawing and painting she also learned to mix colors.

At school Mary is on the girls' volleyball team. She is considered a very good volleyball player. When she plays in front of the net she can spike the ball very well. In addition Mary is also very good in setting and blocking the ball.

## A. INSTRUCTIONS AND LITERAL COMPREHENSION

## QUESTIONS (1-6):

## THE TWINS

Instructions

This is a story about the Adams and their two twins, John and Mary. Please read the story and when you have finished I will ask you some questions about what you have read. (Tell me when you have finished.)

I. Questions (Literal)

1. When is the twins' birthday?
2. What does John like to do?
3. What kinds of books does John like to read?
4. What in the story tells you that John likes dogs? What kind of dog does John like?
5. What does Mary like?
6. Why does Mary look forward to the neighbors leaving for the weekend? What kind of dog does Mary like?

## LITERAL COMPREHENSION QUESTIONS

## SCORING CRITERION

1. (1) A statement indicating June 17.

2. (1) The statement must include at least two of the following: reading mysteries, reading about hockey, science fiction books, playing hockey, a large black dog.

3. (1) The statement must include at least two of the following: mystery, hockey and science fiction books.

4. (a) (1) A statement indicating that John likes Randy's dog or that John frequently mentioned to his parents that he would like a large black dog.

   (b) (1) A statement including a large black dog.

5. (1) The statement must include two of the following: make her own clothing, paint, play volleyball, look after the neighbours' large white long haired dog, going to art classes.

6. (a) (1) A statement including that she likes to look after their dog.

   (b) (1) A statement including a large white long haired dog.

Total Possible Score: 8

## B. MULTIPLICATIVE CLASSIFICATION (INTERSECTION)

### QUESTIONS 1-2

II. Questions (Intersect)

1. What kind of gift can the Adams give John and Mary that both the twins would like? Why do you say that?

   If not a type VIII response, give question 2.

2. You remember that John likes to play hockey, and read mystery and science fiction books. He also likes to play with Randy's big black dog. Mary likes to paint, make her own clothing and play volleyball. Mary also likes the neighbors' large white long haired dog. Now what kind of gift can the Adams give John and Mary that both the twins would like? Why do you say that? (If response "a dog," (Q) can you tell me more about the dog?)

## MULTIPLICATIVE CLASSIFICATION (INTERSECTION)

### SCORING CRITERION

Multiplicative Classes $A_1A_2$

1. $A_1$, $A_2$: $A_1$ and $A_2$ can be any of the following but $A_1 \neq A_2$.

$A_1$ the things that John liked

play hockey
read mystery books
books about hockey
read science fiction books
big black dog

$A_2$ the things that Mary liked

make her own clothing
paint
play volleyball
animals
large white long haired dog

2. $A_1A_2$

big black and white dog
black and white dog
black and white like a dalmation
big and grey dog

Simple Multiplication (Intersection)

I. No response.

II. The object, objects, or collection stated matches only one collection and is one or more of the elements in the collection (either $A_1$ or $A_2$).

II. (a) The object stated does not match or is not in any of the major collections $A_1$ or $A_2$, and has no direct relation to any of the collections.

III. The object stated is not in one of the collections, and it has a functional relation with one or more of the elements in one collection ($A_1$ or $A_2$).

IV. The object stated is not present already, but it clearly resembles the elements of one collection (either $A_1$ or $A_2$).

V. Two or more objects are stated, one or more from $A_1$ and one or more from $A_2$.

VI. The object stated is a simultaneous function of the two collections, however the choice is made in terms of a functional relation, or a partitive relation. The chosen element is not already present.

VII. The object stated is not specifically present already, yet it bears some degree of resemblance to the elements of both collections $A_1$ and $A_2$, and both collections are considered and stated, however only genus is used and not differentia. Bears some degree of resemblance to the elements of both collections ($A_1$, $A_2$), however the similarities are too broad. Usually confined to some of the elements and does not extend to them all.

e.g. a dog, because if they both like one they should get one.
a large dog—a dog that plays because Mary likes a dog and John likes a dog.

VIII. (1) Multiplication of Classes: An explicit reference to all and not to any one particular element. States the common properties of $A_1$ and of $A_2$ and then states how the properties of $A_1A_2$ relate to $A_1$ and $A_2$. Also states $A_1A_2$.

e.g. a black and white dog ($A_1A_2$). Mary likes white dogs ($A_1$) and John likes black dogs ($A_2$).

Scoring

I-VII = 0
VIII = 1

Total Possible Score: 1

# APPENDIX E

## ADDITIVE CLASSIFICATION CONCRETE QUESTIONS

A. Class Construction
  Materials
  Questions and Instructions, I, II

B. Class Inclusion
  Materials
  Questions and Instructions, III, IV, V, VI, VII, VIII, IX, X

C. Predication
  Materials
  Questions and Instructions, XI, XII, XIII

Scoring Criteria
  Class Construction, I-II
  Class Inclusion, III-X
  Predication, XI-XIII

## ADDITIVE CLASSIFICATION CONCRETE QUESTIONS

### A. Class Construction

**Materials**

10 large red rounds
3 large yellow rounds
3 large red squares
3 large yellow squares
2 covers
4 supports

**Questions and Instructions, I-II**

I. The items are identified and the collection is covered (don't mention description and probe until all attributes mentioned).
I am going to ask you to put these counters (pointing to the covered collection) into two lots. Everything in one lot is to belong together and everything in the other lot is to belong together. Everything in each lot is to belong together. What will you put here? (pointing to the left display support). And what will you put here? (pointing to the right display support).

The cover is removed from the collection and the examiner says: Go ahead and do it.

What have we here? (pointing to left).
What have we here? (pointing). (Cover collection for Question II)

II. I am going to ask you to make four lots from these lots, two from this lot (pointing to the covered set on the left) and two from this lot (pointing to the covered set on the right). Everything in each lot must belong together.
How will you do this? What will you put in this lot? (pointing to the left empty support). And what will you put in the other lots? (gesturing along the row of four empty supports).

The cover is removed from the collection and the examiner says: Go ahead and do it.

What have we here? (The questions is repeated for each of the four classes.)

## B. Class Inclusion

### Questions and Instructions, III-X

The examiner states that the yellow rounds are to be removed. They are placed at the upper right, and in view. (State once again if confusion.)

III. The classes are covered. Are there more red ones or more round ones? Why is that?

IV. In these lots (gesturing) are all the square ones red? Why is that?

V. In these lots (gesturing) are all the yellow ones square? How do you know that?

VI. In these lots are some of the red ones round? Why do you say (not say that) some of them are round?

VII. I am going to give you a square one. Will it have to be red? Why is that?

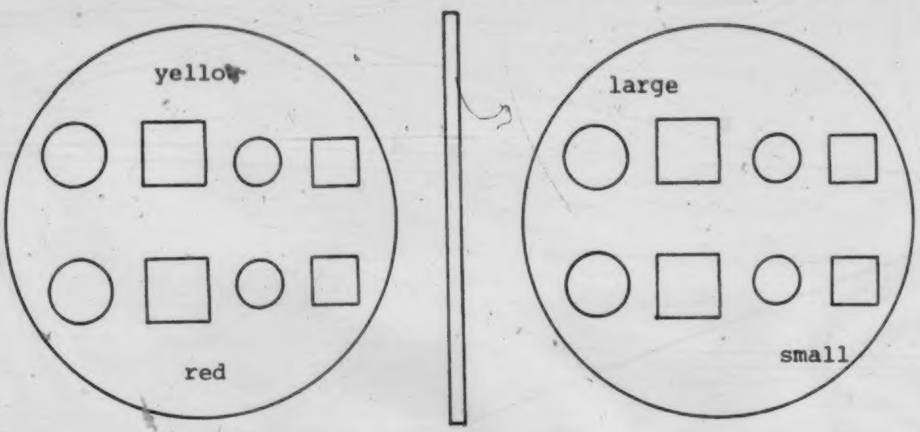
VIII. I am going to give you a red one. Will it have to be round? Why is that?

IX. I am going to give you a yellow one (gesture). Will it have to be square? Why is that?

X. I am going to give you a round one (gesture). Will it have to be red? Why is that?

## C. Predication

### Pattern I


yellow
red
large
small

### Pattern II

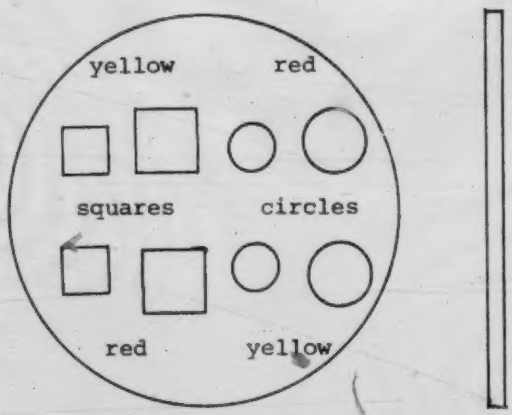

yellow
red
squares
circles
red
yellow

Figure 34

Material Set up for Predication Questions:
Patterns I and II

### Materials

2 large yellow squares
2 small yellow squares
2 large yellow circles
2 small yellow circles

2 large red squares
2 small red squares
2 large red circles
2 small red circles
2 black circles
2 rods
2 coverings

## Predication Questions, XI, XII, XIII

XI. Pattern I is presented. The categories are size and color.

This is a design a boy/girl made. He has put together what belongs together to make a pattern.
Take this rod and put it on the pattern to show how he/she has put together what belongs together.
What pattern does the rod help you see?
How do these belong together?
How do these belong together?

XII. Is there another way to lay the rod to show a pattern?
Put the rod another way to show how the boy/girl put together what belongs together to make a pattern.
How do these belong together?
How do these belong together?

XIII. Pattern II is presented. The category is shape.

This is a design a boy/girl made. He has put together what belongs together to make a pattern.
Take this rod and put it on the pattern to show how he/she has put together what belongs together.
What pattern does the rod help you see?
How do these belong together?
How do these belong together?

## SCORING CRITERIA

Construction of Classes, I-II

I. Items covered and items uncovered. Two classes stated, $B_1$, $B_2$.

(a) all counters are classified
(b) class $B_1$ includes all the counters having the property $b_1$
(c) class $B_1$ includes only the counters having the property $b_1$

(a, b, c are also applicable to $B_2$.)

(d) only two classes are made, no more, no less (extensional simplicity)
(e) similar criteria distinguish classes of the same rank (intensional simplicity)

For full credit (1) the responses for both covered and uncovered situation must be correct.

e.g. (1) Squares, Circles
Circles, Squares

(1) Reds, Yellows

II. Items covered and items uncovered.

Four classes are stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

(a) all counters are classified
(b) class $A_1$ includes all the counters having the property $a_1$
(c) class $A_1$ includes only the counters having the property $a_1$

(b, c are also applicable to $A'_1$, $A_2$, $A'_2$.)

(d) only four classes are made; no more, no less (extensional simplicity)
(e) similar criteria distinguish classes of the same rank (intensional simplicity)
(f) if the class $B_1$ is subdivided into $A_1$ and $A'_1$, and the same criterion is applicable to the class $B_2$ then that class $B_2$ must also be subdivided into $A_2$ and $A'_2$.

For full credit (1) the responses for both covered and uncovered situation must be correct.

e.g. RC, the YC, the RS, the YC
RC, RS, YC, YS

RC - Red Circles
YC - Yellow Circles
RS - Red Squares
YS - Yellow Squares

Total Score: 2.

## Class Inclusion III-X

III. Statement must include "more red" and some major indicator of inclusion. The major indicator of inclusion is that there are red squares (A) and red circles (A') and these make up all the red (B). Only red squares and red circles have to be directly stated or pointed to.

e.g. (1) more red, both red squares and red circles.

(0) more round, because there are more round ones than red ones, because most of them are red ones that's why there's more round ones.

IV. Statement must include "no" and some major indicator of inclusion. The major indicator of inclusion is that some square ones are yellow (A'). Yellow squares must be stated, pointed to or directly implied.

e.g. (1) no, because there are three yellow ones.

V. Statement must include "yes" and a major indicator of inclusion. The major indicator of inclusion is one of the following statements that indicates
(a) all the yellow rounds are gone (or)
(b) there's only yellow squares left.
Either yellow rounds or yellow squares must be stated, pointed to or directly implied.

e.g. (1) yes, because you took out the yellow circles.

(1) yes, you just dumped the C's out here (points to yellow circles).

(0) no, because these ones are red squares and these ones are red circles.

VI. Statement must include "yes" and a major indicator of inclusion. The major indicator of inclusion is that the red ones (B) are made up of red round ones (A) and red square ones (A'). The respondent can either point to the collection of red circles or state that there are a group of red circles. Red circles or red circles and red squares must be stated, pointed to or directly implied.

e.g. (1) yes, because I put the round ones in one lot.

(1) yes, because there are some circles in here (points to red circle).

(0) yes, because there, there you took out the round yellow ones.

VII. Statement must include "no" and a major indicator of inclusion. The major indicator of inclusion involves some statement that indicates it could be a yellow square one (A') or because there are yellow squares (A') and red squares (A). Yellow square must be stated, pointed to or directly implied.

e.g. (1) no, because there's some yellow squares in there.

(1) no, because there's two groups, one's red and one's yellow.

(0) no, it doesn't matter what color you give me.

VIII. Statement must include "no" and a major indicator of inclusion. The major indicator of inclusion involves some statement that indicates it could be a red square one (A') or because there are red squares (A') and red circles (A). Red squares and red circles must be stated, pointed to or directly implied.

e.g. (1) no, because there are round ones and square ones.

(1) no, because there are round ones in there.

(0) yes, because there's only round ones in here so it gota go into this group and its red a red circle.

IX. The statement must include "yes" and a major indicator of inclusion. A major indicator of inclusion is one of the following statements:

(a) only the yellow squares are left (or)
(b) the yellow round ones are gone.

Yellow squares or yellow circles must be stated, pointed to or directly implied.

e.g. (1) yes, you only have a group of yellow circles.

(0) no, it could be round.

X. The statement must include "yes" and a major indicator of inclusion. A major indicator of inclusion is one of the following statements:

(a) only the red round ones are left
(b) the yellow round ones are gone.

Red circles or yellow circles must be stated, directly implied or pointed to.

e.g. (1) yes, because there are only round ones left (should be cued) (red directly implied)

(0) no, because there are two colors red and yellow.

(0) no, it could be yellow round.

Total Possible Score: 8.

Predication, XI-XIII

In general the counters can be grouped on the basis of three main attributes or criteria: size, color and shape. Three main collections are possible, $B_1$, $B_2$, $B_3$, with six dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$.

1. Shape = $B_1$
   Circle = $A_1$
   Square = $A'_1$
2. Color = $B_2$
   Red = $A_2$
   Yellow = $A'_2$
3. Size = $B_3$
   Large = $A_3$
   Small = $A'_3$

$B_1$, $B_2$, $B_3$ can be interchanged and $A_1$, $A'_1$, $A_2$, $A'_2$, $A_3$, $A'_3$ can also be interchanged.

$B_1 \neq B_2 \neq B_3$ $\qquad$ $A_1 \neq A'_1 \neq A_2 \neq A'_2 \neq A_3 \neq A'_3$

All collections or dichotomous classes formed must be identified as either shape, color or size.

Repetition is a direct paraphrase and the same major criterion is used.
(NR - no response)

I. Response however does not identify any of the three major criteria or collections, $B_1$, $B_2$, $B_3$.

e.g. Pattern I: these are all big and little.

II. Forms and states the properties of two collections, however the collections are not mutually exclusive and no one distinct criterion is stated.

e.g. Pattern II: these are all round and square, and so are these.

III. States one principle criterion or collection, $B_1$, $B_2$, $B_3$, and forms one class. (no repetition) Only one class, $A_1$, $A'_1$; $A_2$, $A'_2$; $A_3$, $A'_3$, is stated and the other class is not stated or described.

IV. States one principle criterion or collection, $B_1$, $B_2$, $B_3$, and forms one class. (The class is repeated.) ($A_1$, $A'_1$; $A_2$, $A'_2$; $A_3$, $A'_3$)

V. States one principle criterion or collection, $B_1$, $B_2$, $B_3$, and states two dichotomous classes, $A_1$, $A'_1$; $A_2$, $A'_2$; $A_3$, $A'_3$. (No repetition)

e.g. Pattern I: these are all yellow and these here are all red.

VI. States one principle criterion or collection, $B_1$, $B_2$, $B_3$, and states two dichotomous classes, $A_1$, $A'_1$; $A_2$, $A'_2$; $A_3$, $A'_3$. (The two classes stated are repeated.)

Scoring, Questions XI-XIII

I-II = 0
III-IV = 1
V = 2
VI = 0

Total Possible Score: 6.

## APPENDIX F

## MULTIPLICATIVE CLASSIFICATION CONCRETE QUESTIONS

A. Matrix Structure
   Materials
   Questions and Instructions, XIV, XV

B. Intersection
   Materials
   Questions and Instructions, XVI, XVII, XVIII, XIX

Scoring Criteria
   Matrix Structure, XIV-XV
   Intersection, XVI-XIX

## MULTIPLICATIVE CLASSIFICATION CONCRETE QUESTIONS

### A. Matrix Structure

### Materials

10 red rounds large
3 green rounds large
3 red squares large
3 green squares large
1 square black matrix
1 cover
2 white rods

### Questions and Instructions, XIV-XV

XIV. The materials consist of a random collection of counters as for test item I and a 2 x 2 matrix.
(Uncover the counters and have the subject describe the counters.)
Please describe the counters for me.
(Then cover again.)

How many sections are there? (pointing to the matrix)
When I pick up this rod (X--X) how many sections are there? (the rod is replaced)
When I pick up this rod (Y--Y) how many sections are there? (the rod is replaced)
How many sections are there? (pointing to the matrix)

I am going to ask you to put these counters (pointing to the covered collection of counters) into these four sections. Everything in each section must be the same. So that if I pick up this rod (X--X is lifted and replaced) they will be alike; and if I pick up this rod (Y--Y is lifted and replaced) these will be alike. How will you do this?

So what will you put in this section? (a) (pointing to the upper left section). In this section? (b) (pointing to section b). In this section? (c). In this section? (d).

XV. The collection is uncovered. Go ahead and do it.

Are they in good order when I pick up this rod? (The rod X--X is lifted and replaced) Why is that?
Are they in good order when I pick up this rod? (The rod X--X is lifted and replaced) Why is that?

The subject may recognize that the classes as he has arranged them are diagonally positioned. Two attempts to correct the order are permitted. The questions, "Are they in good order?" are repeated after each attempt.

## B. Intersection

### Materials

5 large green squares
5 small green rounds

### Collection

2 large green rounds
3 small green squares
1 small green round
2 large green squares
1 small red square
1 small red round
1 large black square
1 small black square

1 support
2 covers
2 white rods

### Questions and Instructions, XVI-XIX

XVI. Pattern III is presented. (The collection of counters remains covered.)
This is a pattern a boy/girl made. He didn't finish it. He didn't put anything here (pointing to the empty space aquare at the point of intersection). We want to put something here; one thing. It must belong to this row (gesturing along the row of large squares) in at least two ways and it must belong to this row in at least two ways (gesturing along the row of small rounds). We want to choose one thing. It must belong to this row in two ways and it must belong to this row in two ways (gestures repeated). Just one thing.

What will you put here? Why did you choose that?
If the subject suggests two objects for the intersecting class the examiner repeats, "just one thing."
If the subject's choice is incorrect the examiner asks,
How does it belong to this row in two ways? (pointing to the large squares).
How does it belong to this row in two ways? (pointing to the small circles).
Three minutes are allowed for finding a solution.

XVII. A collection of counters in a random pile is uncovered. Pick a counter that would go there (pointing to space). The subject selects a counter. Why is this the right thing to put here?
How does it belong to this row in two ways? (pointing to large squares).
How does it belong to this row in two ways? (pointing to small circles).
Two attempts are permitted. The collection of counters is covered for test item XVIII and the counter is returned to the collection.

XVIII. There is another thing we could put in that space which would do just as well, "one thing." It would belong to this row in at least two ways, and it would belong to this row in two ways (gesturing). What else could we put in this space that would belong to this row in two ways and belong to this row in two ways? Why did you choose that?

XIX. A collection of counters in a random pile is uncovered. Pick a counter that would go there (pointing to space). The subject selects a counter. Why is this the right one to put here?
How does it belong to this row in two ways? (pointing to the large squares).
How does it belong to this row in two ways? (pointing to the small circles).
Two attempts are permitted.

## SCORING CRITERIA

Matrix Structure XIV-XV

Major Collections $B_1$, $B_2$ and

Dichotomous Classes $A_1$, $A'_1$, $A_2$, $A'_2$

1. $B_1$ = Color

   $A_1$ red

   $A'_1$ green

2. $B_2$ = Shape

   $A_2$ round (circle)

   $A'_2$ square

$B_1$, $B_2$ can be interchanged, $B_1 \neq B_2$.

$A_1$, $A'_1$, $A_2$, $A'_2$ can be interchanged, $A_1 \neq A'_1 \neq A'_2 \neq A_2$.

Major Multiplicative Classes

1. red rounds (circle) (RC)
2. green rounds (circle) (GC)
3. red squares (RS)
4. green squares (GS)

Response Types

I. No response.

II. None of the major collections are stated, $B_1$, $B_2$, none of the dichotomous classes stated, $A_1$, $A'_1$, $A_2$, $A'_2$, and none of the multiplicative classes are stated (RC, GC, RS, GS).

III. Only one major collection is stated, either $B_1$ or $B_2$.

III. (a) Only the two major collections are stated, $B_1$ or $B_2$.

III. (b) Only one major collection is stated, either $B_1$ or $B_2$, and one or more of the corresponding dichotomous classes is stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

III. (c) Only two major collections are stated, either $B_1$ or $B_2$, and one or more of the corresponding dichotomous classes of each of the major collections is stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

IV. Only one major multiplicative class is stated, either of RC, GC, RS, GS. The major corresponding collection, $B_1$, $B_2$, and the dichotomous class is not stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

IV. (a) Only one major multiplicative class is stated, either of RC, GC, RS, GS. At least one of the corresponding dichotomous classes of the major collection is stated, $A_1$, $A'_1$, $A_2$, $A'_2$, and the corresponding major collection is also stated, $B_1$, $B_2$.

V. Only two multiplicative classes are stated (two from GS, GC, RS, RC). Only one major corresponding collection, $B_1$, $B_2$, is stated and one of the dichotomous classes of the major corresponding collections is stated, $A_1$, $A'_1$, $A_2$, $A'_2$.

V. (a) Only two multiplicative classes are stated (RS, RC, GS, GC) and at least one major corresponding collection stated, $B_1$, $B_2$, and one or more but not all four of the major corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$, are also stated.

V. (b) Only two multiplicative classes are stated (RC, RS, GS, GC) and the two major corresponding collections are stated, $B_1$, $B_2$. The two corresponding dichotomous classes, $A_1$, $A'_2$, $A_2$, $A'_2$, for each of the two major collections are also stated.

VI. Only three major multiplicative classes are stated (three of GS, RS, GC, RC), however all the corresponding dichotomous classes are not stated, $A_1$, $A'_1$, $A_2$, $A'_2$, and all the corresponding major collections are also not stated, $B_1$, $B_2$.

VI. (a) ~~Only three~~ major multiplicative classes are stated (GS, RS, GC, RC), all the corresponding dichotomous classes are stated, $A_1$, $A'_1$, $A_2$, $A'_2$, and all the major corresponding collections are stated, $B_1$, $B_2$.

VII. Four major multiplicative classes are stated (GS, GC, RS, RC), all the corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$, of the major collections are not stated and all the major corresponding collections are also not stated, $B_1$, $B_2$.

VII. (a) Four major multiplicative classes are stated (GS, GC, RS, RC), all the corresponding dichotomous classes, $A_1$, $A'_1$, $A_2$, $A'_2$, of the major collections are stated and the two major corresponding collections are also stated, $B_1$, $B_2$.

Scoring for Questions XIV-XV

I-III(c) = 0
IV- IV(a) = 1
V- V(b) = 2
VI- VI(a) = 3
VII-VII(a) = 4

Both XIV and XV must be correct for total score. If XV score is higher, choose score for XIV.

Total Possible Score: 4

## Intersection XVI-XIX

## Major Dichotomous Classes $A_1$, $A_2$ and Major Multiplicative Classes $A_1A_2$

1. $A_1$, $A_2$ can be any of the following but $A_1 \neq A_2$.

   e.g. small, green
   large, green
   square, green
   round, green (green circles)

2. $A_1A_2$ can be one of the following:

   small green square (gs)
   large green circle (GC)

## Response Types

I. No response.

~~II~~ The object, objects or collections stated match only one collection and is one or more of the elements in the collection (either $A_1$ or $A_2$).

II. (a) The object stated does not match or is not in any of the major collections, $A_1$ or $A_2$, and has no direct relation to any of the collections.

III. The object stated is not in one of the collections and it has a functional relation with one or more of the elements in one collection ($A_1$ or $A_2$).

IV. The object stated is not present already, but it clearly resembles the elements of one collection (either $A_1$ or $A_2$).

V. The subject does not rely on only one element but rather states two. Two objects are stated, one from $A_1$ and one from $A_2$.

VI. The object chosen is a simultaneous function of the two collections, however the choice is made in terms of a functional relation, or a partitive relation. The chosen element is not already present.

VII. The object stated is not present already, and both collections are considered, $A_1$, $A_2$, however only genus is used and not differentia. Bears some degree of resemblance to the elements of both collections, $A_1$, $A_2$, however the similarities are too broad.

VIII. Multiplication of classes. An explicit reference to all and not to any one particular element. States the common properties of $A_1$ and of $A_2$ and then states how the properties of $A_1A_2$ relate to $A_1$ and $A_2$. Also states $A_1A_2$.

Scoring for Questions XVI-XIX

I-VII = 0
VIII = 1

For full score of 1, XVI and XVII must be a Type VIII response.
For full score of 1, XVIII and XIX must be a Type VIII response.

Total Possible Score: 2.

PREVIOUSLY COPYRIGHTED MATERIAL,

IN APPENDIX G, LEAVES 304-307,

NOT MICROFILMED.

DIGIT SPAN SUBTEST. Wechsler Intelligence Scale for Children (WISC-R) (1974).

## APPENDIX H

## SUMMARY OF CLASSIFICATION TEST ITEMS

Table 33

A Summary of Classification Test Items: Adopted and Adapted from Rawson (1969) and those Constructed by the Researcher

| | Test Items Adopted from Rawson (1969) | | Test Items Constructed by the Researcher | |
|---|---|---|---|---|
| Additive Classification | CCO | SCO | CCO | SCO |
| Class Construction | I | | | Story (I) Ia(1,2) |
| | II | | | b(1,2) |
| | | | | c(1,2) |
| Class Inclusion | III | Story (I) II* | | |
| | IV | III* | | |
| | V | IV* | | |
| | VI | | | |
| | VII | | | |
| | VIII | | | |
| | IX | | | |
| | X | | | |
| Predication | XI* | Story (I) V* | | Story (I) VIII(a) |
| | XII* | VI* | | (b) |
| | XIII* | VII* | | (c) |
| | | | | (d) |
| | | | | (e) |
| | | | | (f) |
| Multiplicative Classification | | | | |
| Matrix Class Structure | XIV* | Story (I) IX(1) | | Story (I) IX(2) |
| | XV* | X(1) | | X(2) |
| | | | | Story (II) II(1) |
| | | | | (2) |
| Intersection | XVI* | Story (III) II(1) | | Story (III) II(2) |
| | XVII* | | | |
| | XVIII* | | | Story (IV) II(1) |
| | XIX* | | | (2) |

*Adapted. (These consisted of modifications and refinements which were not extensive but involved more than minor phrase changes.)